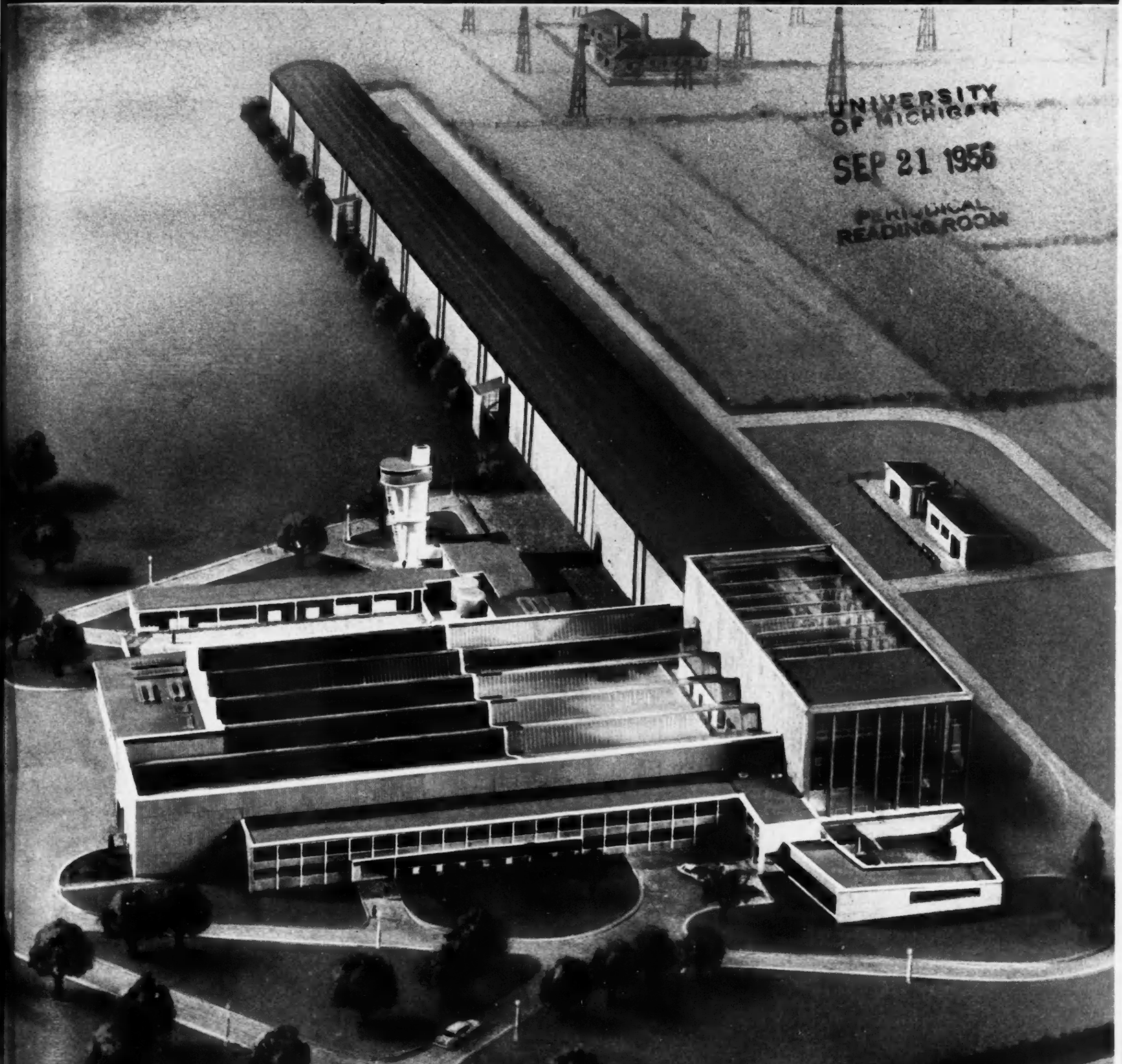
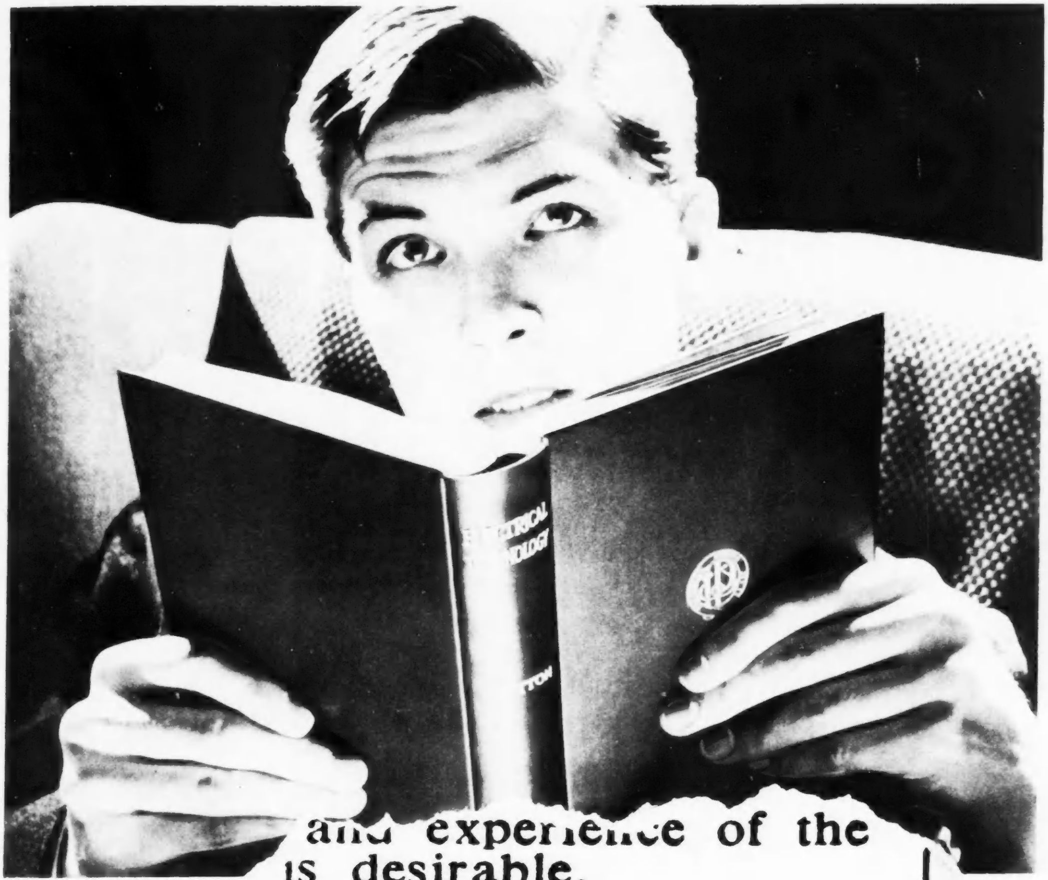
DISCOVERY

SEPTEMBER 1956 2/6





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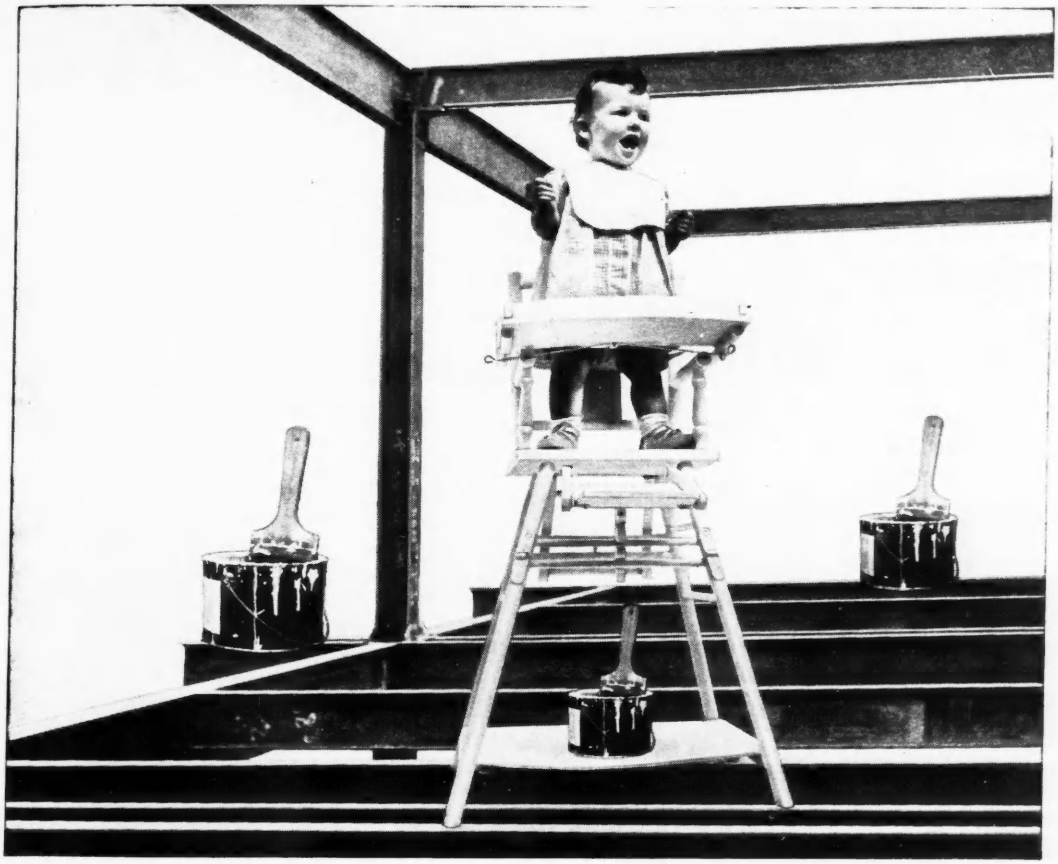

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DISCOVERY

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On our cover this month appears an artist's impression based on a photograph of the new design of the Ship Hydrodynamics Laboratory of the National Physical Laboratory at Feltham. It is fully discussed on p. 353.

Colour photographs of insects appear on pages 372 and 373. Special colour pages will appear from time to time in DISCOVERY.

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THE PROGRESS OF SCIENCE

SHIP HYDRODYNAMICS LABORATORY

The new ship hydrodynamics laboratory now being built for the National Physical Laboratory at Feltham, five miles from Teddington, will be the largest in Europe and one of the best equipped in the world. It will provide bigger and better facilities for experiments with ship models of all kinds than are at present available in the Ship Division of N.P.L. at Teddington, and so make it possible to carry out a much wider range of research into problems which are of ever-growing importance to the British shipbuilding and shipping industries. The main building will contain a long towing tank, a smaller, square steering pond, a basin for vibration experiments, and workshops, instrument rooms, and offices; these appear in the photograph-drawing of a model of the building on the cover of this issue. A separate building, not shown in the photograph, will house a water tunnel and the main electrical plant room. The total cost of the laboratory will be £2 million; construction was begun early in 1955 and is due to be completed in 1959.

The most important problems in ship hydrodynamics are the resistance and propulsion of ships. For the past eighty years, ever since William Froude showed the way, these have been studied scientifically by carrying out experiments with scale models. The earliest resistance experiments were made by towing small models through fairly small tanks—Froude's original Torquay tank was only 250 feet long—but the general tendency has been to run larger models, sometimes 30 feet long, at higher speeds in larger towing tanks. There are several reasons for this, among them that flow conditions over the model hull can be better controlled and difficulties of linking model and full-scale measurements are reduced. Resistance experiments in which the model is towed were later supplemented by propulsion experiments in which the model hull is driven by a scale propeller powered by an internal drive. For such experiments larger models—both hull and propeller—are desirable. However, this is not the whole story why larger towing tanks are the fashion; the early techniques of model testing were confined to reproducing calm water conditions. Today the general trend of ship research is away from the relatively simpler field of steady motion studies, simulating what is almost an idealised ship in an idealised sea, to the much more complicated study of unsteady motions, which represent real ships in true sea conditions. For this reason, the towing tank at Feltham, like one of the two smaller tanks at Teddington, will have a wavemaker at one end so that models can be run into regular head seas. Again, this demands a longer tank. The Feltham tank will be 1300 feet long, 48 feet broad and 25 feet deep—not the longest in the world, but considerably longer, broader and deeper than anything previously built in Britain.

Straight, comparatively narrow tanks are of little use for manœuvring experiments, and Britain woefully lacks any proper facilities for such essential work for merchant ships. A small steering pond, 100 feet square, in which small radio-controlled free models can be manœuvred, is a first step towards filling this gap. Later this pond may be fitted with wavemakers along two adjacent sides so that irregular cross seas can be produced, thus simulating still more closely the conditions in which ocean-going ships operate. Another smaller water tank will be provided in a vibration laboratory where the effects of the surrounding water on the vibration characteristics of ship hulls and other floating bodies can be studied under better conditions than have been previously available; this is another example of the increasing attention now being paid to the study of non-uniform motions.

Experiments on propeller models were originally carried out in towing tanks, either with propellers in isolation or in combination with a model hull. However, sixty years ago cavitation was first encountered on heavily loaded, fast-running ship propellers, and Parsons, who with R. E. Froude was responsible for the detection and naming of this perturbing phenomenon, built a small water tunnel in which to study its effects. This was, in essence, a continuous pipe through which water was circulated past a rotating propeller model, and in which the pressure at the model could be controlled. Since then cavitation difficulties have steadily become more frequent and serious, not only for propellers but also for other under-water bodies, and several large water tunnels have been built to combat them. These later tunnels have a much wider range than Parsons' early variable-pressure tunnel, although they all incorporate its basic elements. At present Britain lacks a water tunnel of sufficient size and range to cope with cavitation problems which will arise in the design of future high-powered merchant ships. The water tunnel at Feltham is intended to remedy this; it will be possible to test larger propeller models in it than in any other tunnel in the world, and it will also be suitable for investigations on fixed bodies such as hydrofoils. A 1000 h.p. pump will circulate the water at speeds up to 50 feet per second through the test section where the pressure can be varied from 1/10 atmosphere absolute to 6 atmospheres absolute. The water circuit itself includes two limbs 14 feet in diameter which penetrate vertically 180 feet below the test section, which is at ground level. Means are thus provided of redissolving cavitation bubbles which are formed at the test body by subjecting them to high pressure before the water in which they are carried returns to the test section.

The unusual, mainly underground construction of the tunnel contrasts with the equally unusual construction, for Britain, of the towing tank, which is being built mostly above ground in order to reduce construction costs. The detail design and construction of the whole establishment is under the supervision of the Engineering Division of the Ministry of Works, and many awkward

difficulties have to be overcome to provide the required degree of accuracy in such large experiment facilities. For example, the precision machining, pointing and alignment of the rails along the sides of the towing tank on which the towing carriage runs is a costly and lengthy operation. Again, the structural design of the towing carriage itself must combine lightness and rigidity for high speed and freedom from vibration with ease of access and convenience of mounting measuring apparatus. Similarly, in the water tunnel the satisfactory design of the model support system is only one of several unusual problems.

The work which is carried out in a modern ship hydrodynamics laboratory falls naturally into three groups. First comes the routine application of well-established model-testing techniques to specific ship designs to assess the performance of the proposed ship and to recommend changes to improve that performance. Second comes research into ways of modifying the established testing techniques and of the methods of relating model and full-scale experiment results. Here the aim is to improve the whole basis of model testing. Lastly comes research into hull forms and propulsion devices themselves so as to develop new and better ships. All three groups today demand an ever-widening application of modern instruments and a better understanding of the fundamental physical processes involved in the flow of water past moving bodies. Contrary to what was often believed in the not-so-distant past, the study of ship hydrodynamics is today only at its beginnings. The new NPL laboratory should play a major part in future developments.

GENEVA IN PRINT

The United Nations conference on the peaceful uses of atomic energy, held in Geneva during August of last year, was not only a landmark for future historians; it was also unique as a conference. Never before had so much information, which in the normal course would have been published by instalments, been first made available at a meeting. There was a need, without precedent, for speed and completeness of publication. It has been met by the publication of sixteen volumes, totalling 7882 pages, in just over nine months from the conclusion of the conference. And this is merely the English-language edition. There are three others in preparation: a French edition, of which four volumes have so far been published, and editions in Spanish and Russian, due for completion this year. In all of them, there will be included not only the 450 papers read at the conference, but also the full text of discussion (including in some cases oral versions amounting to distinct papers), and a further 600 contributions, submitted to the conference, and available only for reference at Geneva. The quick preparation of so much material for printing has depended to an unusual degree on co-operation: on authors and speakers for the checking of material; on the seventy-odd scientific secretaries of sections for efforts "directed primarily towards scientific accuracy"; and on eleven editors named as "principally responsible". No one who has any concern with publishing can feel anything but admiration for their achievement. It has been recognised by the sale, before completion of publication, of more than 2500 sets of proceedings, exclusive of copies distributed officially to authors and governments.

The final impression must be that, just as Geneva was historic as an occasion, so is its record as a document.

Dr. Butement of Liverpool University will shortly review these volumes from a scientific point of view in DISCOVERY.

FLUORIDATION OF WATER

Among the mineral salts occurring naturally in the water of most districts are fluorides. In this country the degree of concentration varies from a mere trace to about 6 parts per million (expressed as fluorine) but is rarely more than 1 p.p.m.

As long ago as 1892 Sir James Crichton Browne reported a connexion between fluorides and diet, affecting the teeth and general health. A quarter of a century later American investigators noted a connexion with the mottling of the enamel of teeth. Not until 1943 was it established that the degree of mottling depended very largely on the quantity of fluoride present in the water.

Meanwhile it was observed that dental decay was less prevalent in districts where mottling from fluoride occurred. Subsequent surveys in the U.K. and U.S.A. indicated that, where the fluoride content in the water was 1 p.p.m. or more, the incidence of caries was about 60% less than where the proportion was smaller, and that mottling was negligible. The investigation was based mainly on dental records of children, but there was some evidence that beneficial effects were carried into adult life.

The first large-scale experiment to see whether the same results would follow artificial admixture of fluoride to waters that were free or almost free from this substance took place at Grand Rapids, Michigan, in 1945. The results were considered so successful that the new process, known as fluoridation, has been increasingly adopted in the various States. The latest figures (June 1956) show that rather more than 22 million U.S. citizens are now supplied with water dosed with fluoride.

In 1951 the United Kingdom authorities sent a special mission to America to study the methods of fluoridation. Two years later they published their report,* recommending that a start should be made in certain areas. Preliminary surveys would have to be carried out to record the prevalence of caries in the chosen areas, the level of dosing determined, and arrangements made for supplies of chemicals and equipment.

First in the field was Anglesey, where fluoridation started in November last. Kilmarnock followed in April and Watford in May of this year. The scheme is controlled by the Ministry of Health or the Department of Health for Scotland, but local authorities may reject it if they so decide. This right of veto seems to have been exercised by Darlington.

* "Fluoridation of Domestic Water Supplies in North America as a means of controlling Dental Caries", H.M.S.O. 5*s.*

The notion of mass medication entertained by some opponents is not well grounded. No claims are made that fluoridation exerts any therapeutic action. Nor is it true that some foreign substance is added to the water. All that is done is to increase the concentration of a substance naturally present in water to a level which appears on the evidence to be most effective for dental and general health.

The fact that the chemicals employed are toxic may enliven hostile propaganda, but the dilution is so great that the objection cannot be reasonably upheld. Special precautions are taken to protect those who handle the chemicals. In this country sodium fluoride has been generally used in small waterworks. Known commercially as SF, it is much more soluble in water than the cheaper alternative, sodium silicofluoride or SSF. The high cost of SF is offset by the relative cheapness of the dosing gear in the form of a saturator.

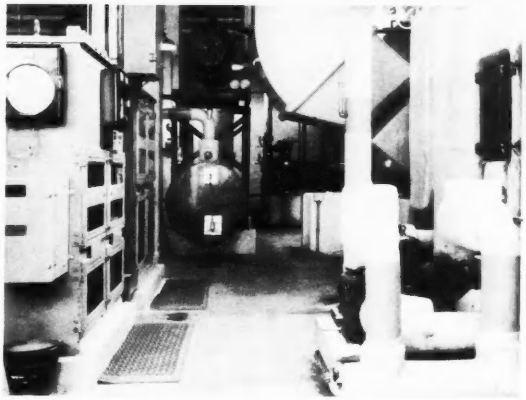
SSF is the chemical most widely used in U.S.A. and will almost certainly be used in larger waterworks here. At Watford, where there are two installations, one uses SF and the other SSF. The waters from the two sources mingle before reaching the consumer. SSF is a by-product from factories that process rock for other purposes. It has the higher fluorine content (60% as against 44% in SF), and the calcium silicofluoride formed in hard water is more soluble than the calcium fluoride formed from SF. The dosing mechanism for SSF is an elaborate dry feeder adjusted to ensure a degree of concentration of 1 p.p.m. The amount fed is continuously recorded so that danger of excess is negligible.

On the general question of the desirability of fluoridation, a minority of the select committee in U.S.A. in 1952 held the view, not that fluoridation would necessarily result in injury to health, but that "it is not known with any degree of certainty what subtle physiological effects may ensue, and that a number of important questions still remain unanswered". On this point the U.K. special mission commented that it was extremely difficult to prove a negative, that no risk was known to exist, and that if it did exist it was so inconspicuous that it had not been revealed by many years of investigation. This view is officially endorsed; and in the absence of positively unfavourable evidence, fluoridation projects are likely to be maintained and developed.

AIR-CONDITIONING AT THE NATIONAL GALLERY

The six rooms reopened to the public on June 15, 1956, represent the latest phase of the rehabilitation of the great collection in Trafalgar Square. The first room to be air-conditioned was completed in 1950, and a further couple of rooms so equipped were available by 1955. Of the six above mentioned, three have full air-conditioning.

A tentative scheme for air-conditioning was put forward in 1936–7 and postponed on account of the national defence programme then in hand. This was fortunate in fact, because it was during the war (when the pictures were in exile in a North Wales quarry) that much of the experience needed for the present installa-



Plant room showing part of evaporator (*centre*), with condenser above, compressor (*back right*), and recirculation pumps (*right foreground*). (*By permission of H.M. Ministry of Works.*)

tion in London was gained. Before that, however two investigations had been conducted by the National Gallery laboratory in close collaboration with the Ministry of Works and DSIR respectively. The first showed the amount of solid matter present in the air of the rooms: it was of the order of 1 lb. per million cubic yards of air, and represented the "load" with which the filters would need to cope. The second experiment concerned the average moisture content (compared with dry weight) of the panel (wood) paintings in the collection. This figure was close to 12%, which means that to achieve equilibrium between the intake and output of moisture throughout the year, a relative humidity (R.H.) of around 58% would be appropriate. Temperature is of less importance; it has been found convenient to provide 63° to 65° F. These then are the basic figures which the air-conditioning plant has been designed to satisfy. It should not perhaps be overlooked that the *sign* of the change in dimension (expansion or contraction) of artists' canvas with R.H. is the same as that for wood, i.e. it expands when wet and shrinks when dry. This is opposite to that of normal canvas, and is due to the hygroscopic nature of the priming with which it is commonly impregnated. But the *magnitude* of change for artists' canvas is close to that for wood.

The purpose of air-conditioning for a picture gallery will now be clear; it is to control the movement of moisture in wood or canvas within fairly narrow limits, and to reduce enormously the degree of pollution by the atmosphere in which the paintings are hung.

No very special features are found in the plant itself; it is more the local details which may be interesting. For example, the filters are guaranteed 99·9% efficient for dust particles down to 2 microns diameter. The air inlet ducts are immediately below the subsidiary glass ceiling, the air entering through grilles of slot form about 2 inches wide and several feet long. Just above floor level are the exit grilles of similar construction, connected with larger ducts leading back to the plant

room, which is situated in a well or "area" surrounded by other parts of the building. By using this space, construction costs were substantially reduced. Also, the plant room is unobtrusive: there is next to no noise, and a minimum of vibration. Space is available for additional machinery or "spares" as needed.

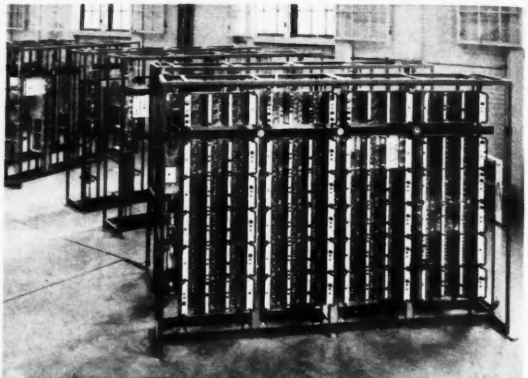
The cycle of operating begins with the mixture of filtered air from outside and recirculated air. The filtered air passes through a hot-water pre-heater battery which is thermostatically controlled by a dew-point element beyond the humidifying chamber, which controls, by means of finely divided water sprays, the quantity of moisture in the air-stream. When the heat-content of the mixed air entering the chamber exceeds the proper value, the pre-heater cuts out, and chilled water from a refrigerating unit enters the water spray. The temperature of the saturated air is thus reduced to the desired figure. The saturated air-stream is then warmed to the appropriate temperature for the galleries and regulated by an element placed in the return air duct. In this sequence of events, three things have happened, namely: (1) the air has been cleaned; (2) it has acquired the correct moisture content; (3) it has been warmed to the desired degree. Now that six rooms are air-conditioned, the plant is working to the capacity for which it was designed originally. The Ministry of Works have been responsible for this interesting application of thermodynamics to the well-being of one of the world's greatest collections of paintings.

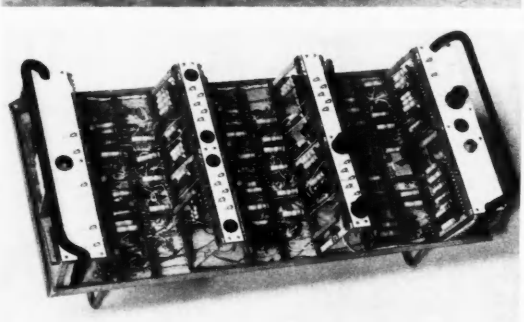
ELECTRONIC CLERKS

Although high-speed electronic computers were originally designed specifically to carry out heavy scientific mathematics, there has been a recent tendency to use them for business work. In the United States a number of the largest and fastest machines are being so used—so far there is only one machine in Britain concentrating on commercial calculations.

It is therefore good to see that Britain has no intention of being left behind in the race for increased business efficiency. The Department of Scientific and Industrial Research has an Advisory Committee on High Speed Computers. This committee recommended that an Interdepartmental Study Group should be formed and the Group has now been in existence since 1954. It reports through the Director of the National Physical Laboratory (NPL) and is made up of representatives of the Treasury, the NPL, and the Ministry of Pensions and National Insurance. The NPL is, of course, expert in the use of computers and the Ministry of Pensions is a likely future user of electronic computing techniques applied to business calculations. The Group has just issued its first report,* which deals solely with the use of computers for payroll calculations.

Despite the obvious potentialities of computers in the business world, the subject is still in its infancy in both Britain and the United States, the only two countries as yet seriously interested. There are two reasons for this. The first is technical: computers as they are at present are by no means ideal for commercial calculations. The second is a matter of scientific effort and interest—the possible methods of application have not yet been studied in detail. The report of the Group is an indication that the second reason is being dealt with already.





Component parts of the new computer under construction at the National Physical Laboratory. These were first shown to the public at the recent Open Day at the National Physical Laboratory.

The Group has chosen a specific example and based all its analysis on it. This example is the weekly wage calculations carried out by the Pay Branch at the Central Office of the Ministry of Pensions and National Insurance at Newcastle. Most of the staff of 3400 considered, are non-industrial civil servants. There are twenty-one different grades, each with a clearly defined basic pay increasing by annual increments to a maximum. The employee's position in a wage scale is determined by age and length of service in the grade and some of them receive one or more allowances. About 3000 work overtime for which they receive increased rates. The example is thus representative of a non-industrial staff or, in fact, any staff not receiving complicated piece-work rates and bonuses.

The computer chosen for the analysis is the DEUCE* which is an engineered version of the NPL ACE Pilot

* National Physical Laboratory: "Wage Accounting by Electronic Computer", H.M.S.O. 2*s*. 6*d*.

* Digital Electronic Universal Computing Engine.

Model. DEUCE, as it stands, has a punched card input and output system which is too slow for commercial work, so a magnetic tape input system which is not yet in existence has been postulated. DEUCE works in binary notation, that is it does all its calculations in the scale of two instead of the more familiar scale of ten. It is a fast machine, the time to carry out basic operations is: addition and subtraction, 64 microseconds; multiplication and division, 2 milliseconds; discrimination, 96 microseconds. These times are based on numbers of 32 binary digits, "bits" as they are called, which are approximately equivalent to 10 decimal digits.

The punched card input and output is adequate for scientific calculations which generally require a relatively small amount of input data for a large amount of computation. When these conditions are reversed, as in most commercial work, the machine becomes very slow. DEUCE is fed with 1280 bits per second from cards, and punches out results at a rate of 640 bits per second. The magnetic tape input which the Group assume, has two input and two output channels each operating at 40,000 bits per second. The card system is retained as an additional input system.

Each week's pay is calculated from two sets of information, the *Standing Conditions Record* which is on magnetic tape, and the *Weekly Input Data* on punched cards. The former contains practically all the information needed for computing the pay, the latter advises changes to individual standing records and information varying from week to week, e.g. overtime. The computer is made fully automatic, that is it has only to be fed with information and have its output extracted. The preparation of the weekly input, which is done by clerks, is estimated to take 43 man-hours, 35 of which must be worked on Thursday or Friday of each week. Such is the speed of electronic computers that the actual time on the machine is only one hour. This brings up the question of the most efficient way of using the machine, and the report has wisely considered two possibilities. The first is the obvious one, that the computer is used solely for payroll work, the latter that it spends the rest of its time doing other calculations, business or mathematical.

Present conventional payroll accounting costs £12,700 per annum, exclusive of overheads. Using a computer, the estimated costs are £16,190 if the computer does nothing else or £2727 if it is used for other work. These figures again ignore overheads but these are expected to be lower for computers than for conventional methods. The total staff, at present twenty-two, would be reduced to eleven and the equipment is assumed to be written off in ten years.

For payrolls of this type it is estimated by the Group that a staff of 5000 would make electronic computation economic even if the computer did nothing else. More complicated payrolls involving complex piece-work rates and bonus systems would be more expensive because of the increase in cost of the staff required to translate the input data. However, the Group points out that when a computer system is used it is relatively simple to extend it to provide automatic costing.

Two points emerge from this detailed analysis. One is that the time consumed in presenting the data in a form acceptable to a computer is, at present, out of all proportion to the time to do the calculations. Presumably future work will concentrate on new methods of dealing with this, either by photoelectric reading techniques or by feeding information in direct from time clocks, etc. The other point is the encouraging financial one that a firm's research department may have a much better chance of getting a high-speed digital computer if the commercial side of the organisation could be convinced that such a machine would demonstrate a direct saving of money.

ANCIENT INSTRUMENTS IN PEKING

It is announced from Peking that the ancient observatory in that city was opened to the public on May 1, 1956, and now displays some of the most ancient instruments and astronomical records in the world. Undoubtedly the most venerable is an "oracle bone" record of a solar eclipse from the Yin dynasty (1300–1100 B.C.), which has been published by Tung Tso-Pin in his "Yin Li P'u". Another noteworthy exhibit is the famous stele with a carved planisphere dating from A.D. 1193. There are also records of sunspots and comets observed in the Han dynasty (206 B.C.–A.D. 220).

Visitors being shown models of old Chinese astronomical instruments at the Purple Mountain Observatory, Nanking. (*Courtesy of Dr A. M. Young.*)

The present Peking Observatory was set up by Kuo Shou-Ching in A.D. 1275–9, some of its instruments showing the stimulus of the mission from Persia by Jamāl-al-Dīn in A.D. 1267. Since the 17th century at least, the observatory has been located on a tower in the eastern wall of the city; another observatory at Yangch'êng, farther south, has a tall tower and a 40-foot long shadow-scale gnomon used by Kuo Shou-Ching.

It is reported that eight of the ancient bronze instruments are on show, including the great celestial globe, an ecliptic and an altazimuth armillary, and the "new" armillary instrument. The two surviving instruments of Kuo Shou-Ching (unless they are the replicas made by Huangfu Chung-Ho in 1437) are kept normally in Nanking at the Purple Mountain Observatory; they may well have been concentrated at the capital for this exhibition. The old instruments were replaced in the 17th century by others designed by the Jesuit Father Verbiest and executed in a typically Chinese style with dragon ornamentation. Some of the instruments were carried off by the Germans after the 1900 Boxer uprising, and were exhibited at the Orangerie in Potsdam until they were returned under the Versailles Treaty. Although several publications have given a general description and photographs of the ancient devices, they have not undergone any detailed examination and measurement of accuracy either in China or during their sojourn in Potsdam. It is to be hoped that the present important exhibition might stimulate such activity.

REACTOR FUEL PROCESSING

Processing of nuclear reactor fuel elements is required to repair irradiation damage and to remove fission products which absorb neutrons. The cost of this processing is at present a substantial fraction of the cost of electricity from nuclear power. Chemical engineers in the Atomic Energy Research Establishment at Harwell are working on projects aimed at reducing the cost of this processing. In a reactor of the type being operated at Calder Hall, the solid bars of uranium fuel are contained in metal cans. Physical changes due to irradiation cause mechanical strains to be set up which would eventually lead to rupture of the fuel cans resulting in the release of highly radioactive fission products into the coolant stream. The fuel elements will be removed from the reactor before this serious state of affairs can arise, but as only a small proportion of the fissile atoms will have been used up at this stage, it will be necessary to treat the fuel so that it can be recycled through the reactor.

The existing processes involve the removal of the metal can by mechanical means, followed by dissolution of the contents in acid, after which the fission products are removed from the solution by what is termed Solvent Extraction. The latter technique has been extensively employed in the petroleum industry for several years, and the general principles are widely known among chemists and chemical engineers. The acid uranium solution is mixed with a substantially immiscible solvent which selectively extracts the valuable fissile (U^{235}, U^{233}, Pu^{239}) and fertile (U^{238}, Th^{232}) materials away from the γ-emitting, neutron-absorbing fission products. The two liquid phases are then separated. Successive cycles are carried out to further purify the uranium and plutonium solutions. The equipment generally used to carry out these operations in practice is either of the "mixer-settler" or the vertical-column type; both kinds have been extensively developed by the chemical engineers working at Harwell. The purification process must be carried out behind heavy shielding because of dangerous γ-radiation from certain of the fission products. The purified liquid is then brought out of the shielding and submitted to successive chemical reactions in order to prepare the uranium fuel in a solid form once again, before finally casting into a fuel element shape ready for the fitting of a new can.

The aim for lower cost fuel processing and refabrication of fuel elements has stimulated interest in the U.S.A., Canada, and Britain in high-temperature metallurgical processes which maintain the fuel in its metallic state (Pyrometallurgy). It was argued that the elimination of the steps which involved the dissolving and diluting of the bulk uranium metal, and then later reducing it back again to the metallic form, would result in an overall saving in cost. In the simplest pyrometallurgical route, the fuel would be decanned, followed by melting to remove fission products in the form of vapours and slags. Fuel element refabrication is still necessary, so that the casting and recanning operations are required. It must be stressed that although research is going ahead on some of these pyrometallurgical operations for dealing with highly radioactive fuels, no industrial process has been developed as yet. Finally, it is important to note that the fission products separated extensively are those which absorb neutrons most powerfully in an atomic reactor, rather than those which emit γ-rays. Consequently, heavy shielding is required for the whole plant, and remote handling of the fuel is required right through from leaving to re-entering the reactor.

A *liquid fuel* atomic reactor, with integral fuel processing, would largely eliminate the need for these separate chemical processing plants. Although the development of such reactors is in a very early stage indeed, one possible scheme, known as the "homogeneous aqueous reactor", may have a reactive *core* of uranyl sulphate in heavy water, the fissile atoms being the U^{233} isotope of uranium. This would be surrounded by a *blanket* containing thorium as the fertile material, possibly in the form of a slurry of thoria in heavy water. Heat would be generated mainly in the core, but also in the blanket; and each system would be circulated through heat exchangers, the rest of the power station being on conventional lines. The contents of the core and blanket would also circulate through equipment designed to separate the fission products such as Xenon gas and rare earth elements which otherwise would tend to accumulate in the reactor and reduce reactivity by the absorption of neutrons. Thus, the chemical separation equipment would be part of the reactor plant. Having once put sufficient U^{233} in the

system to start it up, it may be possible to make the reactor self-sustaining in fissile material, due to capture of neutrons in the fertile thorium atoms present in the *blanket*. The chemical separation problems are great, and much research and development effort will be required to enable the "homogeneous aqueous reactor" to become a soundly engineered and economic reality.

THE LONDON BUS

London's latest double-deck bus, the "Routemaster", which has recently made its début in passenger service, departs in so many ways from conventional automobile practice in this country that it is likely to revolutionise British double-deck bus production. It is a two-axle vehicle, of all-metal construction and seating sixty-four passengers. It has a laden weight no greater than that of the standard 56-seater "RT". Although primarily designed to replace the trolley vehicle, it will also be used as a replacement for the "RT" as the need arises.

In the "RM", or "Routemaster", the aim has been to produce a vehicle for maximum carrying capacity, minimum weight, ease of control, and ease of servicing and maintenance. It is of monocoque construction; no conventional chassis is employed, the body structure serving as the main load-carrying unit, with small sub-frames at front and rear to carry the mechanical units. Independent front suspension and a patented form of coil-spring rear suspension give a wide roll centre to promote stability and improved riding. To keep within the desired 11 tons laden weight, extensive use has been made of light alloys, fibreglass, and other weight-saving materials in the body structure. Basically, the engine is the same as that of the "RT", but the absence of conventional frame and leaf springing has allowed it to be mounted offset towards the near side; the radiator is in an almost horizontal plane under the floor, to the right of and behind the engine. Transmission is via a fluid flywheel and independently mounted epicyclic gearbox. The gear-selector pedal has been dispensed with; direct engagement of gears being by electro-hydraulic means controlled by a column-mounted shift lever. Although operating electrical circuits only, this lever actuates in a gate to provide similarity with London Transport vehicles with preselective gearboxes.

It is appropriate that the first "Routemaster" should have entered passenger service in 1956, the year marking the centenary of the old London General Omnibus Company, and it is illuminating to compare this latest London bus with the General's "B" type of 1910. In the design of both vehicles full advantage was taken of the current regulations regarding length, width, height, weight, maximum speed, and other restrictions, and it should not be overlooked that the almost painful hesitancy on the part of the authorities in easing these many restrictions over the past forty-five years has been an important factor in retarding the development of the London bus. However, a more enlightened outlook exists today, and the vehicle has been able to attain a very high standard. Compared to its ancestor it is longer, wider, more powerful, and—because of its modern suspension, large-section low-pressure tyres,

FIG. 1. A body following horse-bus design, solid tyres, open back, open top, hard seats, no protection for the driver, 28 h.p. petrol engine, 34 seats, unladen weight 3½ tons.

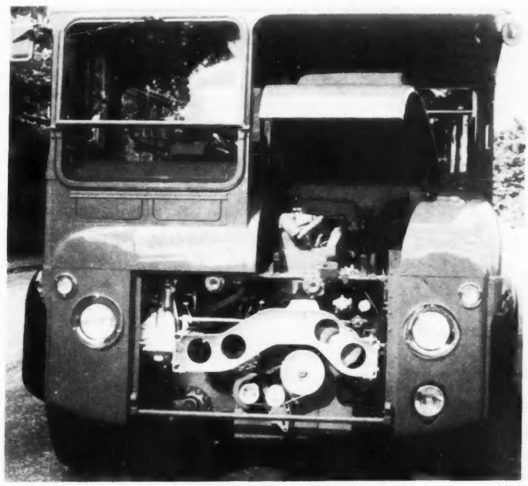


FIG. 2. The "RM" carries most of its mechanical equipment in an easily accessible position under a fibreglass bonnet.

foamed-plastic seat fillings, and completely weather-proofed upper deck—more comfortable to ride in. The driver's comfort has been studied, in the provision of an enclosed cab with heater and adjustable seat; power-operated brakes and gears and windshield de-misters reduce his physical effort or mental strain. The conductor has a roomy and enclosed platform and wide gangways to make his fare-collection easier. Yet the

passenger-weight ratio of the two vehicles is practically the same—sixty-four passengers in a comfortable bus weighing, fully laden, 11 tons, as against thirty-four passengers in a relatively Spartan vehicle weighing 6 tons.

Over the years London bus design has acquired a certain air of datelessness; the "RT" of today is as elegant as its prototype of seventeen years ago. Critics may think that the newly designed "RM" panders to passing taste, but the absence of a conventional radiator cowling is the logical outcome of placing the radiator itself under the floor. To have added a bogus radiator would have been to behave like the designers of some early mechanically propelled carriages, who incorporated an artificial horse's head to avoid frightening real horses!

LIQUID METHANE TANKERS

In the Middle East oilfields and also in Venezuela large quantities of hydrocarbon gases are burnt every day because there is no use for them. Here in Britain and Western Europe we have an acute fuel shortage and many thoughtful people have tried to devise schemes for bringing the gas to Britain. Some years ago, the "Bechtel Plan" was put forward for the construction of actual pipelines from the Persian Gulf to Britain. This sounds fantastic, but the distance is no greater than that over which gas is carried in the U.S.A., and if the countries concerned could all rely upon harmonious relations with their neighbours the proposition would be quite a practicable one. Alas, that condition is far from being fulfilled, and attention is now being turned to the possibilities of liquefying the gas at the oilfield and then bringing it in specially designed tankers across the seas.

This project presents quite a number of novel engineering problems. The liquid methane, at atmospheric pressure, will be at a temperature of $-160°C$, and metals have very different properties at such low temperatures. A disastrous fire was caused by a liquid methane tank at Cleveland, U.S.A., during the war and this was partly attributable to the effect of the low temperature on the mechanical properties of the metal from which the tank was made. Moreover, the tank for liquid methane in such a ship would have to be of very special construction, and it would be quite out of the question to put water into it as ballast for the return journey; indeed it would probably be necessary to leave a certain amount of liquid methane in the tanks all the while, to avoid abrupt temperature changes. The ships will therefore have to incorporate special ballast tanks to enable them to make the return journey.

However, these problems can be overcome and barges are being built to carry liquid methane from the Gulf Coast up the Mississippi and thence by canal to Chicago. Each barge will have five insulated tanks of 50-foot diameter, 25-foot height, the whole vessel carrying the equivalent of 120 million cu. ft. of natural gas. When it reaches Chicago the evaporation of the methane will provide cold for the big cold-storage installations and the vapour will of course be used as a fuel. The first of these barges is now nearly finished.

In Britain the Gas Council is seriously considering the construction of boats which would bring gas from Venezuela to Britain. The major cost of running such a system would be the power needed for liquefaction, but some of this would be recovered if the liquid were evaporated in a refrigerating plant when it reached these shores.

There is no precedent as far as is known for an ocean-going ship being built with insulated tanks to carry fluids at sub-zero temperatures. It is possible that the natural evaporation of the liquid on the journey would serve to keep it cool and at the same time provide the power for the ship's propulsion. Alternatively, it might be better to vent the gas to atmosphere at the mast or reliquefy it by a small liquefication plant on the ship. The calculations so far made suggest that the latter course would be the most desirable.

SCIENCE CITY

Earlier this year it was announced that a \$50 million Science City will be built on 300 acres, formerly marginal ranch-land, on the outskirts of San Antonio, Texas. It is intended that this development, including research facilities and residential and recreational areas, should create an ideal environment for industrial research laboratories and should provide first-class technical manufacturing facilities. Forty large plots have been set aside for such units; one laboratory is already being built, and negotiations are under way for several others. These buildings will be available for long-term leases by industry and will be constructed to meet the specific needs of the occupants.

The scheme is being organised by the Southwest Research Centre, and development will be centred around the two institutions located at this site which at present employ over 600 people and operate on an annual budget of \$5½ million. These are the Southwest Research Institute, a non-profit research trust dedicated to the economic development of the south-west; and the Southwest Foundation for Research and Education, which is devoted to biomedical research, biochemistry, physiology, and agricultural development, and is the largest independent, privately endowed biological research laboratory in the south-west of U.S.A.

Science City will have 2200 homes, and also its own schools, churches, and a shopping centre. There will be recreational facilities, including a swimming pool, golf course, riding stable, and club house. A plot of 200 acres has been offered for a hospital centre.

It is hoped that, in this new city, scientists can work on the problems of the future unhampered by concern with present-day production problems. The idea behind the scheme is that "you can't do much creative thinking in a boiler factory"!

BLOOD GROUPS AND HUMAN EVOLUTION

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Part of an Address to the British Association for the Advancement of Science

It is well known that every human being belongs to one of four blood groups, A, B, O, and AB. This means that his or her red blood cells (or red corpuscles) carry on their surface one or the other of two substances known as A and B, or neither, or both. All the cells of one individual are of one blood group. Though not necessarily the same in parents and children, blood groups are inherited according to well-established rules.

GENETICS OF THE BLOOD GROUPS

Every body cell of every human being contains, in its nucleus, forty-six thread-like bodies called chromosomes. These forty-six consist of twenty-three pairs, the members of a given pair being similar but not identical. Not only are the chromosomes as a whole paired, but the genes on them have a fixed linear order and are also paired in such a way that one gene on one chromosome and the gene in the corresponding position on the other chromosome together control a given character.

Each of the reproductive cells, however, contains only twenty-three chromosomes, one from each pair. At fertilisation the twenty-three chromosomes from each parent come together, and the new complete set of forty-six is reproduced in every cell of the embryo. Each of the two genes (one on each of a pair of chromosomes) which control the blood groups belongs to one of three possible varieties known as A, B, and O. Though, from the testing point of view, O is a negative character, representing the absence of A and B, there is nevertheless a separate O gene. The joint action of two A genes or of an A and an O makes a person belong to group A, of two B's or B and O, to group B; an A and a B gene determine group AB, and two O genes, group O. Each of the reproductive cells of the new individual will, in turn, carry either but not both of the genes received from the parents.

Besides the ABO groups there are now known to be at least nine separate systems of blood groups, each of which can be regarded for our present purpose as genetically independent of all the others and each of which is determined in the individual by a separate pair of genes. Though, for any given system, the individual possesses only two genes, there may, in the population as a whole, be two, three (e.g. A, B, and O) or even more alternative varieties to which these two (which may be like or unlike) may belong (e.g. two A's, an A and a B, etc.).

For any genetical system, such as that of the ABO blood groups, it can be shown mathematically that, in a "random mating population", the frequencies of the genes, and hence the frequencies of the different kinds of individual (i.e. of the blood groups), will tend to remain constant from generation to generation unless certain of the genes have a selective advantage over the others. For the blood groups the overall selective effects in a single generation are slight, and thus, at least over a small number of generations, the gene frequencies in a community may be regarded as constant quantities, characteristic of that community.

GENETICAL DATA AND ANTHROPOLOGY

The vast bulk of blood-group frequency data refers to the ABO system alone, and here we can classify to our heart's content, checked only by classical or morphological anthropology, and by occasional clues from history and archaeology. In general it may be said that where history shows populations to have a common origin they do have similar blood-group frequencies.

There exists, however, a large and growing volume of data on populations that have been tested with regard to anything from two to all nine blood-group systems. We do not, as a rule, find that the classification deduced from one system agrees completely with that deduced from another. If they did agree, we should have available a very satisfactory classification of mankind; but it would be a static classification, with little evidence as to how the existing state of affairs was reached. A consideration of apparent discrepancies has, however, always in science been a fruitful source of new knowledge, and may in the present case lead to an understanding of the processes whereby the existing frequencies arose.

Ultimately, it is thought, all or nearly all bodily characters are controlled by the mechanism of chromosomes and genes, but only in a small proportion of cases can a group of alternative characters be attributed to a single set of alternative or allelomorphic genes on a single pair of chromosomes. Moreover, in many cases the alternative characters are, on the one hand, "normality" and, on the other hand, some severe but rare disease of little anthropological interest. For anthropological purposes we need two or more characters, each reasonably common, and the most important known genetical systems of this kind are the blood-group systems.

There are, however, a number of other such systems, and perhaps the most important of these is that which affects the haemoglobin of the red cells. Practically all Europeans and a large majority of all human beings have a single kind of haemoglobin, haemoglobin A. In Africa between the tropics and sporadically in Southern Europe and Asia, we find that up to 20 or even 40% of people have another type, haemoglobin S (sickle-cell haemoglobin), usually mixed with A. A third variety of haemoglobin, C, reaches frequencies of about 10% in West Africa, where it exists along with A and S. In South-east Asia, another variety, E, partly replaces A, as does D in northern India. Other varieties of haemoglobin, known by the letters G, H, I, J, seem to be very

rare. It appears highly probable that all these varieties, both common and rare, are the products of a single system of allelomorphic genes.

In the Mediterranean area, in Siam, and probably in parts of tropical Africa, a gene of another system gives rise to thalassaemia, or Mediterranean anaemia, by interference with haemoglobin production. Over large areas its frequency is high enough to make it of anthropological importance.

The abilities to taste phenylthiocarbamide and to smell hydrogen cyanide are each (separately) genetically controlled, but the tests are not as precise as could be desired, and the genetical situation is also not entirely clear. If, however, these difficulties could be overcome, the frequencies of the characters concerned would certainly make them useful anthropological markers.

All the characters so far mentioned are inherited by relatively simple genetical mechanisms. This greatly facilitates the mathematical treatment and enables precise predictions to be made of the results of mixing of populations. Perhaps of equal importance is the fact that the blood groups, at least, are fixed genetical characters unaffected by state of nutrition and external influences generally.

With such characters we may contrast the external characters of the body, i.e. the size, shape, and colour of the body and its parts. These are, in the main, inherited, but very little is known about the genetical mechanisms involved. The characters show continuous variation which can be described only in terms of some kind of measurement, whether of colour or size, in contrast to the sharp distinctions which may be made with regard to characters such as the blood groups. It is almost certain that each character (e.g. height, skin colour) is the resultant of the joint action of a large number of genes, so that it is doubtful whether a complete genetical analysis will ever be achieved. Darlington and Mather (1949) have, however, made great advances in the theoretical treatment of characters such as these, determined by what they call polygenes.

Most of the external characters are, moreover, modified in the individual by external influences such as food supply and sunlight, and are not precisely determined expressions of the genes controlling them.

On the whole it may be said that the blood groups and certain other simple genetical characters are much more stable in the individual than the visible external characters, and that many, if not all of them, are perhaps more stable long-term features of the community than are the external characters.

Each of the main external characters is the product of a number of independent genes, presumably on several different chromosomes. For reasons readily explained statistically the frequency of each gene may fluctuate from one generation to the next, but, for a single character which is polygenic, that is to say, determined by the combined effects of numerous genes, it is most unlikely that all the gene frequencies will fluctuate together. Thus, over a small number of generations, especially in a small community, these statistical fluctuations will tend to affect the genetically simple blood groups more than the external characters with their polygenic inheritance.

There can be no doubt that the general picture of bodily shapes and sizes presented by a human community is gradually modified in the course of thousands of years as a result of natural selection; and that such selection has given rise to the close adaptation which the human physique shows, both generally and locally, towards its environment. It was at one time supposed that the blood groups were not appreciably subject to such influences, and hence were almost completely stable as indicators of ancestral relationships. It is now thought that, like external characters, blood-group frequencies change slowly through the millennia, but some of the blood groups may be more stable over long periods than most of the external characters.

While, however, selection operates upon such genes as are present at any moment in a community, it is a prerequisite that there should exist, for each chromosome locus concerned, two or more allelomorphic genes. The ultimate source of such genes is the process of mutation whereby a given gene changes into one of its allelomorphic forms. Such a change is a rare event which, under natural conditions, we can neither control nor predict. Most mutant genes appear to have harmful effects and are rapidly eliminated by selection, but when a mutation occurs which, in a particular environment, increases the chances of survival of its bearer, it will tend to spread through the population.

GENETICS AND EVOLUTION

When Darwin put forward the concept of natural selection as the mechanism of evolution, he was completely unaware of the contemporary but obscurely published work of Mendel, the founder of genetics, and it was half a century before this work became generally known and was confirmed. The initial application of genetics to the theory of evolution was almost exclusively the work of Sir Ronald Fisher (1930). He showed not only that natural selection was fully explicable in terms of genes, but that only if inheritance was by means of discrete entities, such as genes, could natural selection, as we know it, take place.

DISTRIBUTION OF BLOOD GROUPS

Thanks largely to the records of organised blood transfusion services, we know more about the distribution of the genes of the ABO system in man than we do about that of any other set of allelomorphic genes in man himself or in any species of animal or plant whatsoever (Boyd, 1939; Mourant, 1954).

All the three genes of this system, A, B, and O, are found in nearly all known populations, but their relative frequencies vary widely from one population to another. Each continent or major subdivision of a continent has its own general character. Nearly everywhere the O gene is the commonest of the three; in Europe, A is fairly common and B relatively rare. In Africa the preponderance of A over B is less. In Asia, B is very common and over large areas exceeds A in frequency—a tendency which spreads into eastern Europe. Australia

and America are peculiar in that B is almost completely absent from the main aboriginal populations and may a few hundred years ago have been entirely absent. In America the Eskimos in fact possess all three genes; the Indians of the United States and Canada are almost exclusively A and O; while from Mexico southward little but the O gene is found, and it is a tenable hypothesis that in what is now Latin America only the O gene was present before the white man arrived.

These generalisations, however (apart from those relating to the complete absence of one or two genes), refer only to the average values of the gene frequencies or, to use a geographical metaphor, they describe only the general levels for each region, but these are in fact diversified by numerous hills and valleys, for it is a peculiarity of the distribution of the genes of the ABO groups, as distinct from most other sets of genes, that even within quite small areas such as that of the British Isles they show marked frequency variations from one part to another.

There are, as I have already mentioned, at least eight other systems of blood groups, but only for two of these, the Rh and MNSs systems, have we anything like a complete world picture. In the case of the Rh system the gene-frequency differences between continents or other major regions are at least as great as for the ABO system, but within a given area of continental size the local frequency differences are very much less than for ABO. The genes of the MNSs system likewise appear to be fairly uniformly distributed over large areas but the data are less full than for the Rh system.

In the light of evidence of this kind it appears to be a reasonable hypothesis that the major distinctions between the principal subdivisions of mankind took place many thousands of years ago, each subdivision having a characteristic set of frequencies for the genes of each of the blood-group systems. Subsequently, we may suppose that minor local differentiations arose between local races.

In terms of this hypothesis, the frequencies of the genes governing the ABO system have been less stable in the last few thousand years than have those of the other two systems mentioned. Solely on the basis of gene frequency statistics, I had, nearly four years ago, come to such a conclusion. I felt that somehow the ABO genes were being affected by the processes of natural selection more rapidly than were those of the other blood-group systems, but the exact mechanisms involved were far from clear. It was soon after this that Aird, Bentall, and Fraser Roberts (1953) first showed that the frequency of group A was significantly higher among sufferers from cancer of the stomach than among the general population. Subsequently it has been shown that group O is very much commoner in sufferers from duodenal ulcer than among healthy persons; and that there is an excess of group A among sufferers from diabetes. Other relations between blood groups and disease are now suspected to exist, and much work is in progress in this new field.

There is no doubt that the diseases concerned are caused in part by the environment, and despite the late average age of onset of some of them, they do reduce the average number of children likely to be produced by the sufferers. Here, then, we appear to have a means whereby the environment is acting selectively, in the Darwinian sense, on the ABO blood-group genes. I do not wish to suggest that the diseases mentioned are themselves particularly important as agents of natural selection, but we can be almost certain that they are merely the first examples to be discovered of a host of conditions each producing its perhaps slight but cumulative effect. It is still very far from clear how the blood-group genes or their products, the blood-group substances on the surface of the red cells or in the tissues, can affect susceptibility to disease, but the clue may ultimately be supplied by work now in progress on the precise chemical nature of these substances and of the subtle distinctions between them.

It is also not clear why the ABO groups should be more markedly subject to such processes than the blood groups of other systems. This is perhaps connected in some way with the fact that the A and B substances, and antibodies reacting with them, are found in a great variety of animals and plants, giving rise to wide possible ramifications of selective action, whereas the substances connected with the MNSs and Rh systems are mainly confined to man and the Primates.

VARIETIES OF HAEMOGLOBIN

For the most clear-cut instance of interaction between genetical constitution and environment we must turn from the blood groups to the haemoglobins. Most adults possess a single type of haemoglobin, haemoglobin A, but in tropical Africa many persons have a second type, haemoglobin S. The occurrence of these two haemoglobins is controlled by a pair of allelomorphic genes. Most people, even in Africa, are homozygous for the haemoglobin A gene (not to be confused with the blood group A gene) and possess only haemoglobin A, but about 15% of the population of all tropical Africa are heterozygous and have a mixture of the two types. Heterozygotes of constitution AS almost certainly have, as we shall see, a rather greater chance of surviving to marry and have children than have normal AA homozygotes; but if we make the conservative assumption that they have equal chances we can calculate the probability of two parents each transmitting a gene for haemoglobin S to their child, and we deduce that about half of 1% of all births must consist of homozygotes for haemoglobin S. Such homozygotes, apart from a small persistence of the foetal type of haemoglobin, have only haemoglobin S. The S variety of haemoglobin, when deprived of oxygen, becomes insoluble in the red-cell fluid and crystallises inside the cell, distorting its shape to something supposed to resemble a sickle. This is liable to occur each time a cell, in the course of circulating in the blood, gives up its oxygen to the tissues, and the process is reversed when it is reoxygenated in the lungs. Thus the red cells rapidly become damaged and destroyed, a process known as haemolysis.

Hence homozygotes for haemoglobin S mostly suffer

from a severe anaemia, known as sickle-cell anaemia. Most homozygotes die from this disease in early childhood, though probably a small but unknown proportion of them survive to adult life and have children.

Heterozygotes possess the two haemoglobins: there is usually more of A than of S, but we must, for the moment, resist the temptation to speculate as to why the amounts are not equal as we should expect. The two types can be separated from the natural mixture by the process of electrophoresis, but when the mixture, inside the red cell or in free solution, is deprived of oxygen there is no separation but the mixture solidifies or crystallises as a whole. Its solubility is not, however, as low as that of pure haemoglobin S; the transformation of red cells to the sickle form can fairly readily be produced *in vitro* but probably rarely takes place in the body. This agrees with the observation that heterozygotes enjoy almost completely normal health and only under exceptional circumstances, such as during high flying in non-pressurised aircraft, are they subject to any disability referrable to their peculiarity.

The theoretical frequency of homozygous sicklers is about $\frac{1}{2}\%$ of the total births in tropical Africa, and reaches 4% in some tribes. Many if not most of the homozygous babies will die without leaving offspring. If this elimination were not compensated in some way, the gene for haemoglobin S would be reduced to a low frequency in a few generations and would ultimately die out. In order to account for its present high and presumably persistent frequency, two main hypotheses have been considered. One such hypothesis demands numerous mutations or changes from the gene for haemoglobin A to that for S in every generation. In order to compensate for the losses of haemoglobin S genes by the death of homozygotes it would be necessary for a proportion of the order of 1% of haemoglobin A genes to mutate in each generation. Most mutation rates that have been measured, whether by indirect means in man or more directly in other organisms, are of the order of 1 in 100,000 per generation, and a rate of 1 in 100 is far outside the range of known rates, so that it cannot seriously be entertained. The other theory is that heterozygous AS persons have more offspring than have those of either homozygous type, AA or SS. This situation is known as one of balanced polymorphism. It is clear that AS persons have more offspring than have those of genotype SS. To prove this hypothesis it would be necessary also to show that AS people had more children on the average than AA people. It is difficult to demonstrate such a situation directly, but the hypothesis would receive great support if it could be shown that AS people were in some way healthier than AA people.

In the probably analogous but more confused case of thalassaemia, already mentioned, it was suggested by Haldane (1949) that heterozygotes for the thalassaemia gene were more resistant to malaria than homozygous normal people. In the case of haemoglobins A and S, the possibility that heterozygotes had a special resistance to malaria was considered by Raper (1950) and by Brain (1952); the fact of such resistance was first clearly demonstrated by Allison (1954) and subsequently confirmed by numerous workers, especially Raper (1956).

There can now be very little doubt that this effect explains the persistence of sickling in Africa and elsewhere. It should be added that the increased resistance of heterozygotes is mainly, if not entirely, to one type of malaria, the malignant tertian type, due to the parasite *Plasmodium falciparum*. The mechanism of resistance is not fully known but is probably by means of the better ability of the parasite to grow on haemoglobin A than on haemoglobin S.

With these clues to guide us, we realise that the frequency of the haemoglobin S gene in a given population must be due, at least in part, to the local incidence of malaria to which recent generations have been exposed. Thus we may suppose that, before the institution of effective anti-malarial measures, something like an equilibrium had been established for each population between the rate of malarial infection and haemoglobin gene frequencies. With the rapid elimination of malaria which is now taking place in many areas, the genes are no longer in equilibrium with the environment, and a process of evolution must be taking place, leading to a new genetical equilibrium.

RATES OF CHANGE OF ANTHROPOLOGICAL CHARACTERISTICS

We are here faced with a dilemma that will become more and more pronounced as anthropology takes more and more cognisance of genetical and evolutionary processes. We are, on the one hand, using gene frequencies as indices of relationship between populations and, on the other hand, seeing them being modified by the environment. Some genes, including probably most of the blood-group genes, are influenced only very slowly by the environment and are stable indicators of relationship. Others are more sensitive to the environment and so, while easier to investigate physiologically and medically, are less reliable as evidence of distant ancestry —but the differences are in every case differences in degree only; it is likely that every gene is ultimately subject to environmental control and that every gene is in some degree an indicator of relationship, even if over only a few generations. The study of the interplay between heredity and environment which together determine the frequency of genes and of characters is a growing field in which anthropology and genetics on the one hand and pathology and physiology on the other are mutually enriching one another.

Even when considered from the standpoint of pure classification, however, the varying rates of frequency change of different characters are in some ways an advantage. The stable characters enable us to classify mankind into broad major races within each of which all members may be presumed to share a common ancestry about ten thousand years ago. If, however, some characters had not responded to varying environments by undergoing selection within that period, we might be unable to make any subdivisions of the major races at all. Fortunately, we have the ABO blood groups

which seem to respond to selection in periods of the order of two thousand years, and in some areas we have the haemoglobins which may so respond in only a few hundred years. Ultimately, when we know more about the present-day responses of genetical characters to the environment, we may be able to set up something like a hierarchy of probes of varying length into the past, the longer ones defining broad and stable divisions, the shorter ones smaller and less stable subdivisions of humanity.

The examination of human remains dug up by the archaeologist gives us much more direct information about individuals and races of the past. This information is, however, limited in two ways: firstly by the small numbers of bodies available, and secondly by the possible unreliability of the blood-grouping tests. Unless the bodies are highly fragmentary or distorted, linear measurements are comparable in accuracy with those made on the living, or on fresh corpses. Blood-group determinations, however, are not always possible, and when they are carried out the degree of accuracy, though it may be high, is always in some doubt since adequate control tests cannot be performed: there is considerable scope for improvements in technique.

I have so far spoken as though natural selection were the only process giving rise to gene frequency differences between populations. In small communities, however, random frequency fluctuations occur and may have a cumulative effect known as "genetic drift". The most important fluctuations are those that result in the total loss of a particular gene, when the few persons who happen to possess that gene die without passing it on to the next generation. There can hardly be any doubt that in some very small communities that have been examined, the unusual or exceptional blood-group frequencies found are the results of such fluctuation. Since, however, a compact isolated community is also ideal for the operation of natural selection, it must not be too readily assumed that every anomalous blood-group picture found in a small community results solely from gene frequency fluctuation or drift.

So long as blood groups were taken to be neutral in relation to natural selection, genetic drift appeared to be the only possible source of the wide frequency variations observed. The vast interbreeding communities of recent historic times were, however, too large for any important random frequency fluctuations to occur. It was therefore assumed that the fluctuations had taken place before the advent of civilisation, when man was still a rare animal existing precariously in small communities. With increase in food supplies, numbers increased, and the accidental gene frequency distributions were perpetuated. It seems impossible with our present knowledge to decide how far it was such a process and how far it was natural selection that determined the broad continental frequencies of some genes that seem so thoroughly stabilised in the major races.

In the particular case of the American Indians the hypothesis of drift in a small community entering America from the north-west has been put forward with particular insistence, and it is indeed difficult to see how the characteristic gene frequencies of this race (for MN and Rh, for instance) could have arisen sufficiently rapidly simply by natural selection in the few hundreds or even thousands of years that these peoples may have spent in a uniform environment, and yet have subsequently persisted apparently unchanged over thousands of years to give rise to the remarkably uniform gene distribution which we now find in the greatest variety of environments from the Arctic through the tropics and on to the extreme south.

Let us now turn to the visible and measurable external characters of the body. These have been for untold mellenia the diagnostic criteria of "race", and they were until recently the only characters available to the physical anthropologist. The colours of the skin and hair are affected in the individual by exposure to sunlight; the size of the body is affected by nutrition; but these are, under normal circumstances, minor effects; the principal factor determining the characters is heredity.

Unlike the differences between the blood groups, nearly all the observed differences are of degree rather than of kind, and scientific accuracy demands precise measurement of the gradations. This is relatively easy in the case of differences of size; the stature of the whole body and the dimensions of its parts can be measured with simple instruments such as callipers. Colour differences are more difficult but not impossible of measurement. The basic data of physical anthropology consist mainly of measurements of length. Great effort and ingenuity have been expended in the mathematical treatment of such data, so as to enable them to be used in comparing populations and estimating the degree of physical relationship between them. Since however, little was known until recently about the mechanisms of inheritance of the continuously varying characters, little of this mathematical treatment makes use of genetical concepts. It was indeed at one time supposed that these characters, whether in man or other organisms, were inherited other than by means of chromosomes and genes, the mechanism which had already been shown to account for the heredity of qualitative characters and differences. It has now been shown for many continuously varying characters, in a variety of animals and plants, that each such character (after making allowance for the effects of the environment) is the result of the combined effects of a number of genes, known as polygenes. Sir Ronald Fisher (1918) carried out a pioneer study on some of the human characters, and Dr Tanner (1953) has followed this up.

GENETICS AS A BASIS FOR PHYSICAL ANTHROPOLOGY

There can be no real incompatibility between the information supplied by blood groups and that yielded by morphological characters. Each kind of evidence must add to the information yielded by the other. From time to time, however, instances are discovered of apparent discrepancies between racial classifications based on blood groups on the one hand and on morphological characters on the other. Sometimes, too, the evidence of one blood-group system appears to be at variance

with that of another such system. In Europe, for instance, ABO blood-group zones run approximately at right angles to those for the Rh groups. Allowing for the different rates and mechanisms of selection it is usually not difficult to suggest at least a possible explanation for such situations.

HUMAN HISTORY

There is little doubt that the final steps in brain development, from advanced ape to primitive man, took place somewhere in Africa or southern Asia. The rate of evolution of the brain and of the containing skull may have been very rapid indeed without necessarily being accompanied by any marked change in the other parts of the body, or in such characters as the blood groups, all, we may suppose, well adapted to local conditions. Then the ability to communicate by speech and to use tools enabled small groups of families migrating from the primitive surroundings to dominate progressively a wide variety of different environments and ultimately to colonise almost the whole world.

To a large extent the environments themselves were adapted to suit the newcomers, but some features of the habitat could not be adapted; and only in so far as he could adapt himself by evolution could man survive in them. Thus there came about the development of a great variety of local physical types. And more subtle biochemical and physiological characters, among them the blood groups, had also to undergo selection and in many cases to arise by mutation and spread by selection. We have hardly begun to understand how it is that particular blood groups are favoured by particular environments, but, as we have seen, it is already known that a number of diseases, related to such features of the environment as diet and infection, affect preferentially persons of certain blood groups, and so serve as agents of selection. It may thus be that the wide variations in gene frequency within blood-group systems, and the large number of the genetically separate blood-group systems possessed by man, are an essential part of the response by what was originally a local tropical species of Primate to the very varied climatic and ecological conditions with which it was faced.

Such a genetical flowering, analogous in many ways with the birth of a host of reptilian species in the Triassic period, and of mammalian species in the Eocene, probably took place in a number of stages mostly corresponding to the ends of the successive glacial episodes. The process is continuing, but is for the moment masked by the great mixing of recent centuries. It was, however, almost certainly after the end of the last glaciation, the Würmian, that the major subdivisions of the human race, as we know them today, were established. To this period we must attribute the laying down, mainly through selection, but perhaps in part by random gene frequency fluctuations in small tribal groups, of the broad genetical constitution of these races, a constitution expressed on the one hand in their well-known physical characters and on the other in the more stable parts of their blood-group pictures.

In the relatively short succeeding period, migration and mixing have carried populations and genes to and fro over the earth, but selection has had a marked effect upon relatively few characters; among these we must almost certainly include the ABO blood groups, and quite certainly some of the haemoglobin variants.

Despite its slow operation we cannot doubt that evolution is continuing. We may hope even to be able to observe it and measure its rate as, for instance, in producing a diminution in frequency of the gene for sickle-cell haemoglobin in a malaria-free environment Allison, 1956). This, too, is an example of how civilisation, by removing some of the cruder selective agencies, may have an effect which can truly be described as eugenic.

A study of such processes in action here and now would be in keeping with the present spirit of anthropological research, and a manifestation of the development, to which I think we can look forward, of a unified physical anthropology firmly based on the whole of human biology. Such an anthropology will take into account all the anatomical and physiological characters of man, tracing, where possible, their development by the methods of palaeontology and embryology, and studying their relationship at the present time both to heredity and to environment. Above all, it will include an examination of the interplay between the last two factors, to the mutual enrichment of physical anthropology and of all the other biological sciences of man.

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RESEARCH ADMINISTRATION

E. S. HISCOCKS, M.Sc., F.R.I.C.

For the past twelve years Mr E. S. Hiscocks has been Secretary of the National Physical Laboratory, the largest laboratory of the Department of Scientific and Industrial Research. Under the Director he is responsible for general administration, accounts and personnel, as well as for the central workshop, photographic section, and Test House. He was formerly a research physical chemist, and during the war was head of the Technical Branch of the Raw Materials Department of the Ministry of Supply.

We are all fascinated by the results of scientific research yet, unless we earn our living at it we have little idea of the forethought and organisation which go to making much modern research possible. Many scientists themselves have only a hazy conception of the nature, magnitude and variety of the problems in management and administration arising in, for instance, a modern large laboratory. Much has been written in the business Press about scientific management, but little systematic attention has been paid in this country to some aspects of the management of science. Yet research is big business. Its current annual cost in U.S.A. alone is estimated to be 4500 million dollars.

Governments are big investors, but unfortunately much of their present expenditure is necessarily for defence. However, many of the results also benefit civilian industry. Management may have little to do with discovery; but in research, much of which is the laborious and painstaking accumulation of data by scientists and their assistants, the organisation of these processes so as to make the best and most economical use of men and materials is very important.

The principles of organisation are much the same in all research laboratories whether chemical, engineering, or of any other kind, since the basic purposes of all of them are common—the pursuit of new knowledge, its assembly, codification, and dissemination. The organisation of these processes must aim at giving the greatest possible freedom and encouragement to the spirit of inquiry and invention, consistent with the discipline necessary to keep the organisation together as a purposeful unit.

In the present century we have seen laboratories grow from small units centred mainly on one man, into large establishments employing hundreds and sometimes thousands of people. Research has changed from a craft to a large-scale industry. It has borrowed and adapted ideas from other branches of industry and applied them to its own needs, but only rather haphazardly.

SPREADING THE LOAD

An important tool in industrial management is devolution. Scientists, by training and often by personal inclination also, seem to dislike using this tool. It is very useful and, no doubt, salutary for, say, a chemistry student to do as much as possible of his own glass-blowing; but for him to continue to do this when he is a salaried member of a large research organisation is probably a waste of time and money. Indeed, a professional glass-blower would probably do the job far better in less time. In other walks of life it was realised long ago that more can be achieved by people spreading the load and developing specialisations than by one person trying to do all parts of the job himself.

We have, in a modern laboratory, a complex organisation of scientists, technicians, assistants, clerks, draughtsmen, and so forth, each doing their appropriate job. Broadly, all the non-scientists have enabling functions, that is, all their efforts should be directed towards supplying the needs of the scientists and producing and maintaining the conditions in which the scientists can get on with their jobs with the minimum of interference and distraction. The "support ratio", that is, the number of staff employed per qualified research worker, varies from two to five or sometimes more. Staff wages and salaries will account for anything from 60 to 85% of the running costs of an established laboratory. Time of staff is therefore very valuable and the organisation of the laboratory must be devised with this in mind. Equipment is, in general, cheaper than staff, and equipment which will save staff time is a particularly good investment.

For instance, observations can be spoken into a microphone suspended in front of the observer and the record can go straight to the office for typing. This can release an assistant for other scientific work. It has also been found, by a time-and-motion study of many routine laboratory operations, that by a reorganisation of the equipment and instrument panels the time taken on a series of experiments can be shortened. For

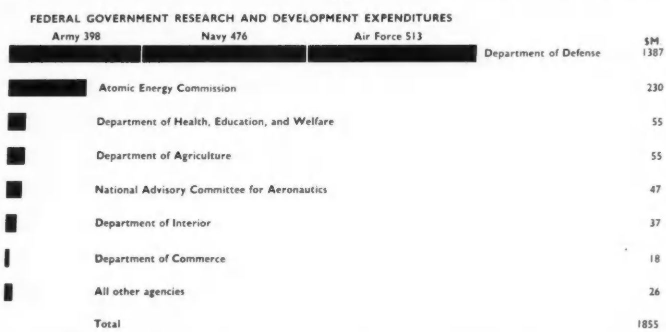


FIG. 1. The expenditure in 1954 by the United States Government on research and development. The figures are for operating costs only and do not include capital expenditure for new research and development plant. These figures are taken from "Administration of Research", New York University Press, 1956.

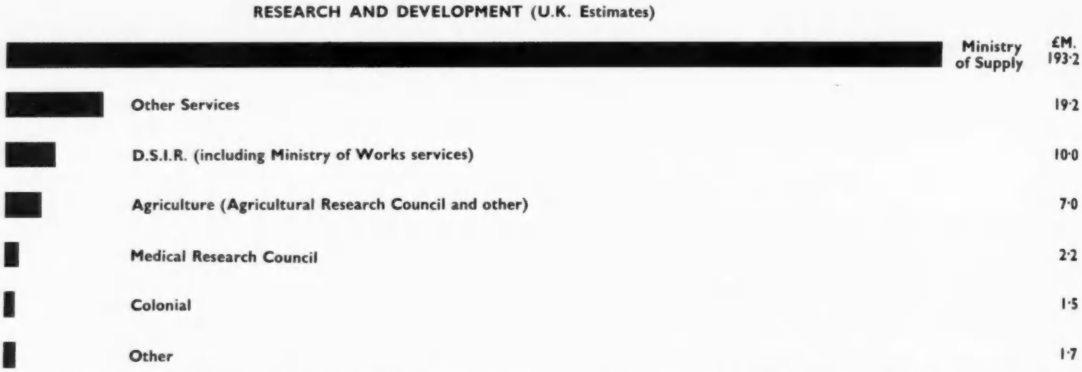


FIG. 2. The British Government's estimated expenditure on research and development for the current financial year. The figures are derived from the 1956–7 Civil Estimates and Estimates for Revenue Departments.

example, in the National Physical Laboratory (NPL) equipment for the testing of thermometers has been redesigned so that by means of foot and hand controls the various thermometers can be moved horizontally or vertically, thus making it unnecessary for the observer to jump up and down. This not only saves time and energy but enhances the quality of the observations.

The distinction between scientist and non-scientist is not very clear in some cases. This applies particularly to the sub-professional assistants and, functionally, to the senior professional men who, as they rise in the hierarchy, spend increasing amounts of their time on organisational and administrative work. Although they may be in close touch with the scientific work, and may even set up the targets and act as umpires, they are actually some distance from the firing points. These people often seem not to recognise the change in their function and may frequently be heard criticising the ways of administrators, not appearing to recognise that they themselves are regarded by their younger colleagues as now being administrators rather than scientists. The director of a large laboratory (one having a total staff of more than, say, 400) will almost certainly not be the director of the actual research. This work will fall to his section heads who will be the real directors of research, while the titular director will be the director of the establishment.

The director of the establishment will probably spend much of his time "selling" the results obtained by his staff and thereby ensuring adequate finance to enable his establishment to continue and expand. He will also be the chief bulwark against outside pressures on his staff. Internally, his chief job will be to inspire and guide his organisation and to get his staff to work harmoniously together. In some types of industrial organisations drive and initiative must come from the top, but in research they come from "the men at the bench" if the conditions are right.

In this country it is usually regarded as essential that the leader of a research organisation should be a scientist, and the more eminent the scientist the more likely he is to be asked to direct a research organisation. But the good scientist is not necessarily a good administrator. He must, therefore, set about making up any deficiency in administrative experience by study, or he must have close to him someone to guide him.

In the U.S.A. there have been numerous conferences on problems of research administration, but in this country, apart from a small number of conferences organised by the Industrial Research Committee of the Federation of British Industries and conferences within the Civil Service, little has been done until very recently. In the spring of this year the Department of Scientific and Industrial Research (DSIR) organised on behalf of the Organisation for European Economic Co-operation a conference on the rational organisation of industrial research at which representatives from seventeen countries exchanged their experiences.

THE RIGHT SUBJECT FOR RESEARCH

The outstanding problem of research administration is, of course, the choice of the right subject for research. This cannot be emphasised too strongly. Too often researches are started when, had the problem been specified more exactly, it would have been seen that there was in fact no problem, or that even if the

FIG. 3. The Glass-blowing Laboratory at the New Research Laboratory, Plastics Division, ICI, Welwyn Garden City.

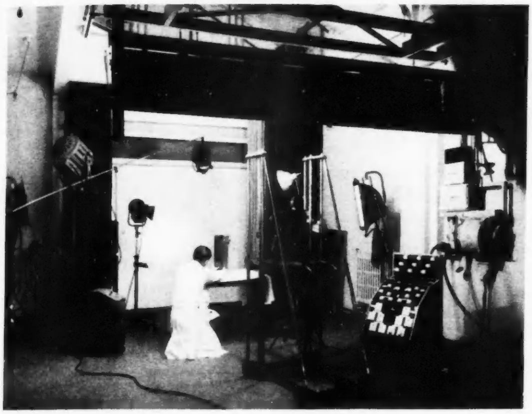


FIG. 4. A photographic studio in the National Physical Laboratory.

experimental work was successful the answers obtained would not give the required information. Next to the problem of choosing the right subject, is perhaps the problem of knowing when to stop a research. Too often, research workers carry on with the research after the law of diminishing returns has begun to operate. This is often particularly so when a man has spent most of his life working in one rather narrow field.

Between these two extremes of starting and finishing research we have all the problems of general research administration. The scientist is more important than his equipment and therefore the outstanding requirement is the choice of the right people to do the work; in large laboratories this brings with it the need for the systematic selection and assessment of staff, the grouping of staff into effective teams, and the setting up of an unobtrusive control of work which will guide the energies of these teams into the required directions without in any way stultifying initiative and creativeness.

Another group of research administration problems is that dealing with the siting and design of laboratories and the provision of their numerous services. In research, accommodation which is appropriate today may need to be very different a few months later. Much work has been put into the design and building of flexible laboratories so that the grouping and sizes of rooms, the distribution of facilities such as water, compressed air, current at various voltages, etc., can be modified easily to suit the changing requirements. Laboratories also need libraries, workshops, canteens, lecture halls, and many highly specialised facilities peculiar to the particular work of the institution.

PUBLISHING RESULTS

In addition to carrying out research the scientist has the duty of making the results of his work known to others. Unless he is engaged on defence work the results of original work are normally published in the journals of the learned societies, but this type of publication does not meet all the requirements of modern industry. Many smaller firms do not employ scientists, and these firms get much of their technical information through trade journals and from the booklets and pamphlets published by organisations such as DSIR. Even then, there is a duty on the scientist to tell the general public something of what is happening in science; this applies particularly to the Government civilian research establishments, who are after all supported by public funds. Not only is the printed word used for this purpose, but the newer media of radio and television also have a large part to play. Some of the ideas of science are too complex to be put into simple language understandable by the non-experts but there is certainly plenty of room for greater popularisation.

NPL SYMPOSIUM

The growing importance attaching to planning for research and its administration is further recognised by the choice of "The Direction of Research Establishments" as the subject of the next in the series of international symposia held at the National Physical Laboratory. At this symposium, to be held this month, leading scientists and research administrators from government establishments, industry, and universities of many countries will discuss problems of importance to those who have to allocate the finance and other facilities for research, those who have to administer and manage large research establishments, and those whose work is directing the research itself. As Sir Henry Tizard* has written, "It is as easy to waste money on research as on anything else; especially if it is someone else's money."

What appears to be the first book on laboratory management† to appear in this country sums up the situation as follows:

"Research in the immediate past has been an expanding industry, with a buoyant market. But the time may come when the pressures of too little money, and especially of too few men for the work that needs doing, will have to be matched by an increasing drive towards a wise economy of resources.

"True economy does not consist in a nibbling-away at minor expenses, but in a re-assessment of our method and organisation in doing our scientific work. The use of judgment in selecting projects, and even more in rejecting them; the ability to divert all the research strength on to one investigation while holding fire on others; the willingness to accept 'near enough' rather than perfection in some fields of work while never losing scientific integrity; these are some of the qualities that the scientist administrator must bring to the laboratory economy. A readiness to experiment in methods of management is essential at this stage in the development of scientific research. Skilful management can contribute greatly to the expansion of our scientific knowledge and may possibly be one of the most effective contributions to its future growth."

* Sir Henry Tizard, G.C.B., A.F.C., F.R.S., "A Scientist in and out of the Civil Service", Haldane Memorial Lecture, 1955.

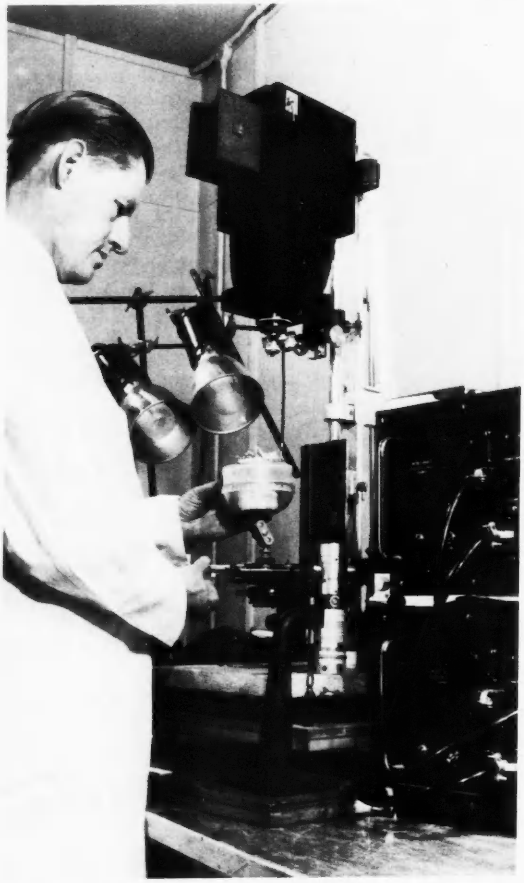
† Laboratory Administration", Macmillan. In the press.

PHOTOGRAPHY IN PLANT PEST AND DISEASE CONTROL

CLIVE CADWALLADER, F.R.P.S.

Shell Photographic Unit, London

Millions of tons of vital food crops are lost annually through the destructive activities of pests and diseases. It is therefore extremely important that farmers and growers should recognise early signs of any disease so that they may take action before damage is irreparable. It may also happen that scientific investigation shows a certain period of a pest's life-cycle to be particularly vulnerable to counter-measures. Photography, especially colour photography, has become a useful aid to the entomologist and plant pathologist wishing to study such cycles. Photographs may also help to instruct farmers and market gardeners, who can learn with their help to recognise the symptoms of disease and the cause of damage.



Clive Cadwallader, a Unit photographer, preparing an insect for photography with the Watson "Holophot". In the background are two 1000-j electronic flash heads; and on the right are power-packs supplying the electronic flash lamps. (*Shell photograph, 1956.*)

During the past five years the Shell Photographic Unit has made a unique study of the more important pests and diseases occurring in the British Isles and throughout the tropical and sub-tropical zones. DISCOVERY is pleased to present two specimens from its extensive colour library.

A photographic programme of this kind involves much exploratory work. Material must often be examined under a low-power miscroscope or hand lens to test its photogenic qualities. Cameras are used varying in size from 9 by 12 centimetres to half-plate, all fitted with extensions allowing for interchange of lenses of different focal lengths. Micro-Tessar type photomicrographic lenses are used for recording specimens in the lower magnification range, and a magnification of over 50 diameters can be obtained.

For work involving high magnification a Watson Holophot combined camera and microscope is used. Larger subjects need a half-plate Kodak Specialist camera, which is mounted horizontally on sliding carriers on an optical bench. Exposures are calculated with an S.E.I. photometer which covers the wide range of light values met with in this type of work.

Highly evolved insects sometimes respond too strongly to the heat of studio lighting, and these may have to be exposed to a low temperature before photographing. Alternatively they may have to be anaesthetised, always provided the natural appearance of the insect is unaltered either by muscular contraction or change in colour. Some insects, such as the greenhouse white fly, have a coating of wax which is easily damaged by the solvent action of anaesthetising vapours. Another difficulty is that the body moisture of insects may evaporate in a few seconds, rendering the subject useless for photography.

These are only a few of the problems facing the photographer, but the new laboratories for the Shell Photographic Unit opened recently in London afford all possible technical assistance. They are fitted with modern processing and printing equipment and can handle both direct reversal and negative/positive colour systems of photography as well as black-and-white bromide printing.

If further information is needed about the availability of these photographs, inquiries should be addressed to The Shell Petroleum Company Limited, Public Relations Department, No. 1 Kingsway, London, W.C.2.

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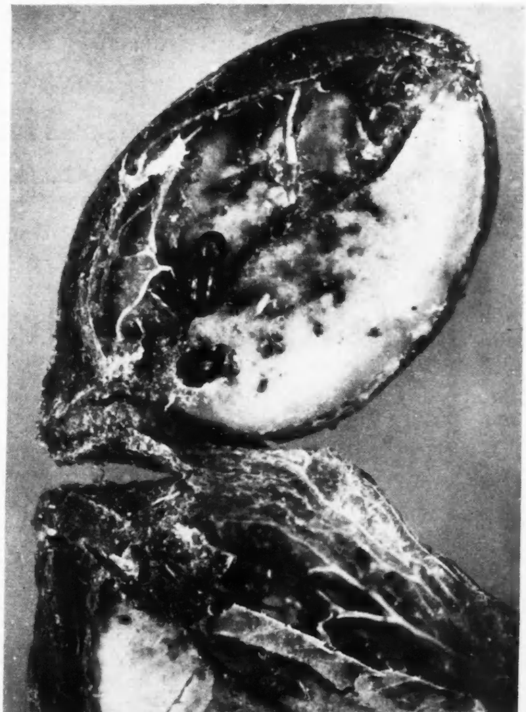

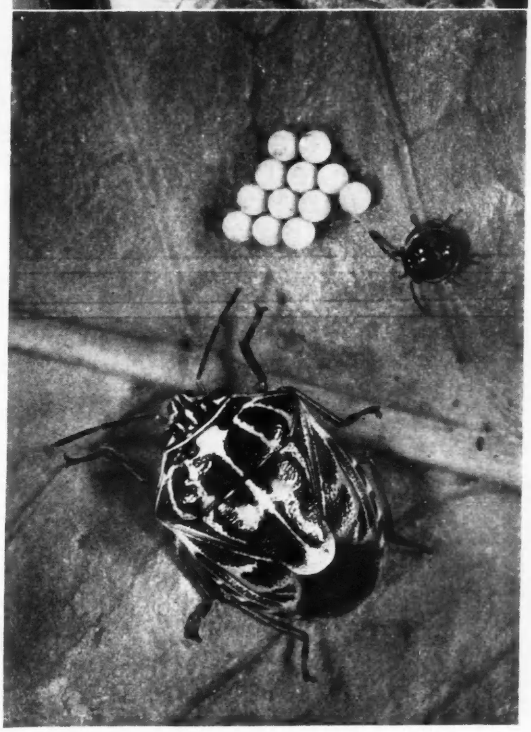

Above: A coffee-tree in Kenya is being banded with the insecticide dieldrin, against the Mealybug Ant (*Pheidole punctulata* Meyr). The Mealybug Ant is not itself a pest, but it protects the serious coffee pest, the Mealybug (*Planococcus Kenyae* Le Pelley) from its natural enemies, and allows it to thrive. Attack directed at the Ant therefore destroys the Mealybug.

Top right: Adult beetles of the Coffee Berry Borer (*Stephanoderes hampei* Ferr), showing the damage caused to coffee berries (Neg. mag. × 7).

Lower right: Adult, nymph, and eggs of the Pentatomid Bug (*Antestia faceta*), an important coffee pest (Neg. mag. × 4). (*Shell Photographs, 1955.*)

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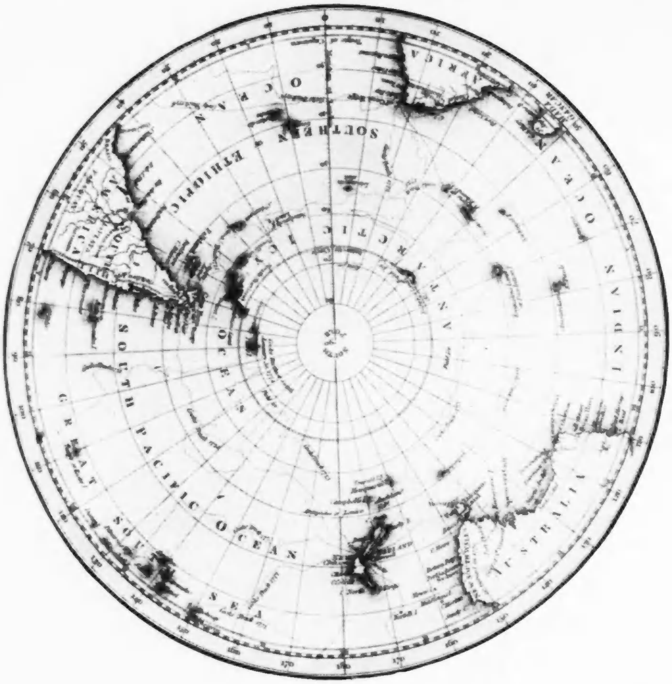
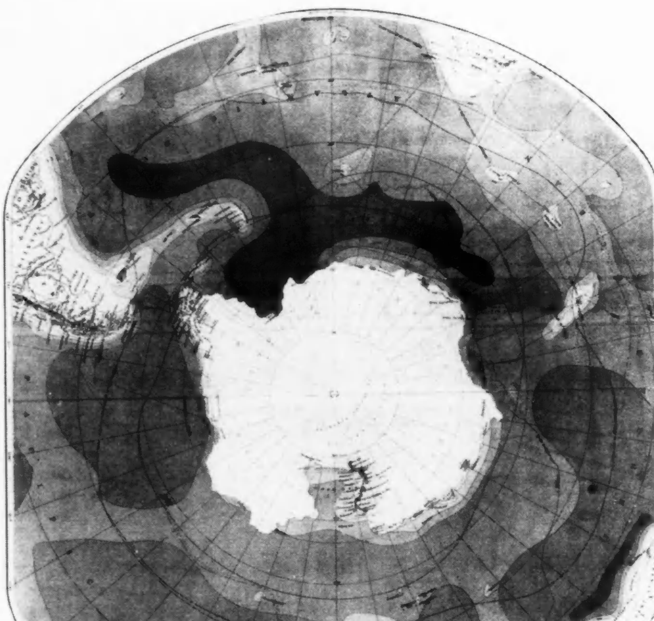
Left: A group of adult Desert Locusts (*Schistocerca gregaria* Forsk) on foliage.

Above: An adult Strawberry Ground Beetle (*Pterostichus vulgaris* L.) on a strawberry. (*Shell photographs, 1955.*)



THE ANTARCTIC
1840

Plate from "A New and Accurate Atlas", published by Richard Holmes Laurie in London, c. 1840.



THE ANTARCTIC
1900

"South Polar Chart" published by Edward Stanford, London. 1901.

Both maps from the Collection of the Royal Geographical Society.

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TWENTIETH-CENTURY MAN AGAINST ANTARCTICA

SIR RAYMOND PRIESTLEY, M.C.

A shortened version of the Presidential Address to the British Association for the Advancement of Science, 1956

As Sir Raymond Priestley's address is of importance to all who are following the activities of the International Geophysical Year in Antarctica, we are publishing it in this extensive form in lieu of our usual monthly IGY notes.

Antarctica is remote: it has therefore still to a great extent the fascination of the unknown. The oceans surrounding it teem with life as do no other waters in the world. For half a century whaling man has followed in the explorer's track to farm these seas. The continent these waters surround is practically devoid of life, and this is due primarily to the fact that over most of it there is no single month in the whole year in which the mean monthly temperature is above the freezing point of fresh water. Low winter temperatures, no matter how severe, are not incompatible with the existence of highly organised life-forms. They are therefore not a serious obstacle to civilised man with his present knowledge. Maximum winter cold is one record Russia can justly claim, though only just, for Canada and the United States are not far behind. Yet in no countries is scientific man more firmly installed or more at home than in these three.

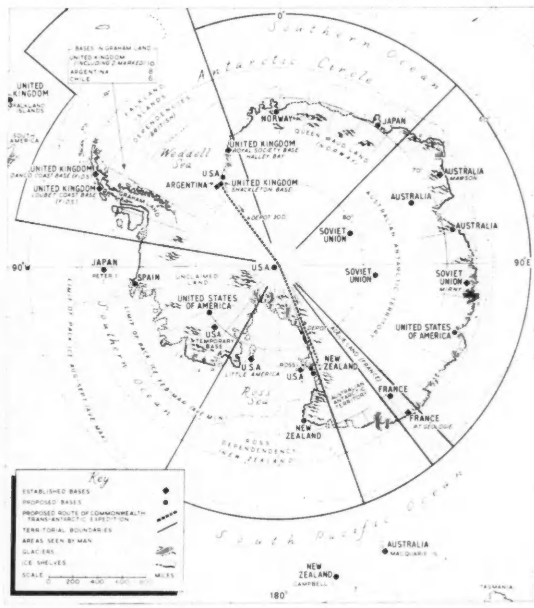
THE PRE-WAR YEARS

The story of the recent history of exploration in Antarctica is a fascinating one. Before 1900 the defences of the continent had been breached by a Norwegian seaman so keen to make a first landing that he pushed aside his superior officer and sprang thigh-deep into icy sea. A year or two later this same Norwegian adventurer, Carstens Borchqrevinck by name—a man of parts if not of punctilio—backed by an English publisher, had spent the first winter on the Antarctic continent at Cape Adare and made the first tentative push inland on the Ross Barrier, a trivial but a significant record. Much greater things were to follow soon.

The first fourteen years of the 20th century have been named the heroic age of Antarctic exploration. The tale is a fitting element in the surge of geographical exploration that was a feature of the peaceful Victorian and Edwardian reigns when major wars were rare and a steady approach towards an eventual Utopia—at any rate for Europeans—was a normal expectation of life. This surge of Antarctic discovery opened with a sharpening of international interest and in cordial co-operation. European scientific societies, under royal patronage—more common than now—conferred politely about spheres of interest. Scientific or quasi-scientific leaders were chosen, or chose themselves; old, tried equipment and methods—the Nansen sledge and cooker: men, dogs, and Arctic tents, were translated to a new field and the 20th-century Antarctic race was in full swing. Robert Falcon Scott was our chosen leader, and, in the Franklin-McClintock tradition, the Navy our selected arm and man-hauling our chosen method: the first to our undying glory, the second to our lasting advantage, the third to our immediate detriment.

By 1904 the more accessible parts of the Antarctic coastline had been the temporary homes, for one or two years, of European teams with a strong complement of natural scientists. These first scientists were fortunate, as we now know, in the location of their headquarters. Biological and geological discovery went on apace, and we gained our first slight knowledge of the physical condition of Antarctic ice and atmosphere. In the meantime sledge parties penetrated for many miles along the coast and made the first tentative essays inland.

The Swedes, under Otto Nordenskjold, were fortunate in their location and lucky in their bad luck. They lost ship and gear, crushed in the polar pack, and pioneered in living on the Antarctic land. They survived with



The Antarctic 1956. (*Copyright* DISCOVERY.)

Progress of Transport in the Antarctic, 1900–50

FIG. 1. *1911. Man Power.* Early in the Antarctic spring, shortly after daylight had returned, Captain Scott with Lt Bowers, Dr Simpson and Lt Evans left the hut for a two-weeks' reconnaissance sledging journey to the western side of the Strait. (*Photograph taken by Herbert G. Ponting, F.R.G.S., F.R.P.S., F.R.Z.S. and copyright by Paul Popper Ltd.*)

courage and cheerfulness through two difficult years, during which they collected evidence of several former Antarctic floras; afforded a good example of international co-operation by being rescued by an Argentine naval vessel, and left behind them in Argentine occupation the first permanent Antarctic weather station. This last had results that were to be of some importance when the temper of the world had changed.

French, German, Belgian, and Scottish expeditions contributed to the mass assault with notable but unspectacular results. From this international effort there were three important exceptions. Norway and the United States, who had considerable polar experience, were both looking towards the Arctic at this time. Imperial Russia, who many years before had produced one outstanding Antarctic explorer, Bellingshausen, had relapsed into her usual introspective mood.

I have left the British effort until last, for, while it was, geographically speaking, the most notable of all, it also leads naturally on to the second phase—the quest for the southern Pole—which fixed the attention of the civilised world upon Antarctica for several exciting years. This was the heyday of the polite recognition of national spheres of interest, and we started with a long lead through the chance that James Ross had approached Antarctica in the season 1840–1 at the place where the continent is most deeply breached by the sea. Scott effected a landing as far south as 78°, and no one by ship could do better even today. His men penetrated deeply into the continent. Employing archaic sledging methods inherited from the Franklin search in the Arctic, but gradually evolving an efficient sledging technique within these limitations, sledge parties set a pattern that was to cost us the Pole and several valuable lives. They learned that scurvy was not a menace confined to Arctic travel and long ocean commissions. On the southern journey the mere suggestion that his breakdown from scurvy was a cause of comparative failure produced in an extraordinary man an obsession which was to govern the rest of his life and give a name to Shackleton Base today. The curious chance that one of Scott's officers had served with Jackson in Franz Josef Land, led to their employment in Antarctica, with further diversion of the British mind from that real polar sledging treasure—the dog.

In 1908 Shackleton made the greatest leap forward towards either Pole that any leader ever made. He traversed the Ross Barrier 300 miles from front to rear, and when the mountain ranges curved across his path, struck up the longest valley glacier in the world, and penetrated over the plateau in face of a galling headwind and below zero temperatures to within ninety-seven sea miles of the Pole. It is fair to say that by the

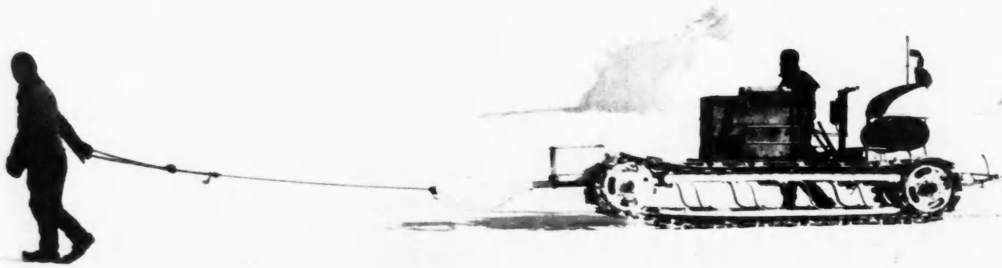


FIG. 2. *1911. The First Motor Sledge.* Captain R. F. Scott was the first to take a motor sledge to the Antarctic. "Then when the famous Captain Scott was preparing for his great Antarctic Expedition in 1910, some tractors were designed for him by the Wolseley Company. They were of the caterpillar type and were fitted with four-cylinder air-cooled Wolseley engines of 12 h.p. with special means for heating the carburettors. There were many novel features about these machines. The treads had spikes with which to grip the ice, but there was no steering gear, brakes or reverse. Two forward gears were provided, giving a speed of 2 and 3½ m.p.h. respectively. Experiments and trials were carried out in Norway, as the result of which certain modifications were made. Orders for three similar motor sledges were also received for use by the Deutsche Antarktische Expedition." From "Wolseley" by St John C. Nixon. As the two tracks could not be worked independently, a man called "the helmsman" had to walk in front of the sledge, pulling it to port or starboard when it was desired to change direction. Lt Evans is here seen guiding Day's motor sledge past the bergs. (*Photograph by Herbert G. Ponting, copyright Paul Popper.*)

time he turned back, a decision surprisingly discreet to one who knew the man, we knew exactly what the southern Pole was likely to be like. The only surprise to Scott and Amundsen three years later was the fact that a ski-stick could be pushed its whole length into soft snow at the centre of what we used to call the Glacial Anticyclone. Shackleton returned—but only just. Forty-eight hours' fine weather on the Beardmore Glacier when the party was on starvation rations and looking for a depôt was typical of "Shackleton's" luck as we knew it in that wonderful year.

The story of the Amundsen-Scott race is well known. Within a month two parties of five men stood at the South Pole. One did not return. The British lost the race and gave their lives because their methods were less than the best. We did most of the approach work to both Poles and were beaten at the post because we did not fully understand the value of dogs as transport animals nor how to get the best out of those we used. There were other factors contributory to the tragedy, but the stark fact is that with sledging rations completely devoid of vitamin C the margin of safety of any man-hauling party to the South Pole from any base on the rim of the continent is too small. Scott made errors of organisation for which he more than atoned by the manner of his death. He should not have changed his parties from two units of four men to one of three and one of five. By doing so he endangered the party coming home, who had, without measuring or weighing apparatus, to take three-quarters of the food from dozens of weekly bags, and he handicapped his own party psychologically by crowding them in a tent meant for four men and disorganising a very carefully thought-out routine. He made a bad mistake in taking on a party of four officers and one long-service seaman. Seaman Evans was in a thought-tight compartment by himself and was naturally the first to break. The weather was unkind. Only recently an American scientist has pointed out that of all the years of which a meteorological record has been kept, 1912 was the stormiest on record and the winter of 1912 set in unusually early. Nevertheless scurvy was, I believe, the decisive factor. Under man-hauling conditions four months is about as long as a sledging man can live on rations devoid of vitamin C. Then nervous and physical deterioration are bound to set in, sores to refuse to heal, and lassitude to supervene. Scott's southern party did not starve to death.

Australia launched her first Antarctic venture in 1911, and by 1914 Douglas Mawson had proved his status as polar leader, polar scientist, and traveller, and had set a record of endurance. Losing one member of a three-man sledge party down a crevasse with most of their provisions, he saw another die of exhaustion at his side and then, alone, staggered along for three weeks, to arrive at his base one day after his ship had left for home.

In the autumn of 1913 I was with Prof. David at his Blue Mountain home when the news was flashed across in the first wireless communication ever sent from Antarctica to civilisation without relay, in itself a significant milestone in Antarctic history. Mawson, staying south a second year, more than doubled his results which, with the time lag characteristic of our Antarctic scientific memoirs, are still coming hot from the Australian Press today. These years also saw the birth in the minds of Bruce and Ernest Shackleton of a significant idea still unfulfilled—the Trans-Antarctic plan.

What were the dividends that accrued from these early 20th-century explorations? Polar geological research revealed evidence of past changes of climate. Antarctica is a continental shield that has remained relatively stable through the ages. Piled upon it are horizontal sediments, a record of its denudation and of the profound changes of level that have occurred as the aeons passed. West Antarctica we think of as a prolongation of Andean folds. Between the two lies the so-called Ross-Weddell Graben. We still cannot be certain, as we were certainly not in 1914, whether or not the severance is complete though evidence from air survey makes it probable that Antarctica is one land mass and not two.

On this continent, in 1914, we found *Archaeocyathus*, a common ancestor of sponges and corals, occurring in Cambrian limestone—stunted forms, but evidence of warmer areas. Coal seams seven feet thick of Permo-Carboniferous to Rhaetic Age were found in the Beacon sandstone that caps the horst that dominates Victoria Land. From the Priestley Glacier came part of a Rhaetic tree containing in its tissue a tiny winged spore. From the upper ranges of the Beardmore Glacier—collected by a disappointed and weakening party, and carefully depôted a few miles from where they died—came 40 lb. of priceless specimens including *Glassopteris indica* type fossil of the Permo-Carboniferous, widely spread in Australia and elsewhere. From the fold-ranges of West Antarctica, Nordenskjold and Gunnar Andersson collected in succession Jurassic, Cretaceous, and Tertiary floras culminating in *Fagus Antarctica*, the southern Beech. In all our wanderings no single formation of undoubted glacial origin was found older than the late Tertiary age. This remains the outstanding problem of Antarctic geology. Perhaps palaeo-magnetism may yet provide the missing clue and Wegener be proved finally right or wrong.

Pre-First World War exploration was also responsible for the Compañía Argentina de Pesca, which has just celebrated a jubilee, its fiftieth year of whaling. Thus the first shore-based Antarctic whaling station stems from Nordenskjold, as did the permanent weather station. Norway must take the credit for most major technical improvements in whaling, from the basic small, fast whale-catching vessel to the harpoon gun. Today whalebone is the least valuable portion of the whale, and it and the tail flukes are the only parts discarded. There are rumours about today that whalebone, once used for ladies' stays, may become a raw material for artificial silk.

THE FIRST WORLD WAR

In 1914 Antarctic exploration was interrupted rather than inhibited by the First World War. Until unrestricted submarine warfare set in, some of the old polite conventions remained. Shackleton left for the

south in pursuit of his Trans-Antarctic quest after having offered ships and men to the Admiralty and having been told to go ahead. Shackleton never showed himself a greater leader than when he brought crew and shore party safely through this second completely unsuccessful expedition without the loss of a single man. Crushed in the ice of the Weddell Sea, the *Endurance* was lost with most of her records and practically all her specimens.

The boat voyage from Elephant Island to South Georgia was an epic. Shackleton, the sailor, made little of it. Shackleton, no mountaineer, dramatised the scramble across the South Georgia ranges. Shackleton, the undefeatable, made four attempts in tiny ships to rescue his marooned companions and at last succeeded. Then Shackleton, the versatile, donned army uniform and became a clothing and equipment expert in Murmansk. I served both with Shackleton and Scott and very briefly met Amundsen in mid-career. A colleague wrote: "As a scientific leader give me Scott; for swift and efficient polar travel, Amundsen; but when things are hopeless and there seems no way out, get down on your knees and pray for Shackleton." Shackleton Base for a Trans-Antarctic Expedition is right.

FIG. 3. *1935. Dog transport.* Dogs have always played an important part in Antarctic transport and are still today fulfilling a useful role. This illustration by the U.S. Naval Antarctic Expedition, 1935, under Admiral Byrd, shows the dog-driver and a biologist, J. E. Perkins, setting out for a brief journey. (*U.S. Navy Photograph.*)

THE INTER-WAR YEARS

As Europe and America recovered their poise, two trends both important to Antarctic exploration can be recognised. America awoke to Antarctica and brought to her aid all the resources of modern mechanical science. Shackleton, Scott, and Mawson had taken the first halting steps in this direction without success. In 1908 I had my first motor-car ride in McMurdo Sound near 78° S latitude in an open Arrol-Johnston car with air-cooled engine and with wheels. For ten miles we did thirty miles an hour on windswept sea ice and then met snow and stopped. Scott's first tractors had little better fate. Mawson's aeroplane crashed in Adelaide in 1911, but journeyed to Antarctica as an alleged air-propelled sledge, and stayed at or near headquarters when there. But in the thirties Byrd used tractors and aeroplanes with success and on the grand scale. He flew to the Pole and back, and in 1937 Ellsworth flew across the continent, landing several times on the way. These were major feats and pointed to a new era to come, in which wireless telegraphy, not an unmixed blessing, but an essential that once available could not be ignored, combined with many other mechanical and electrical aids to transform the Antarctic scene.

Meanwhile, in West Antarctica developments of equal interest to the polar specialist were taking place. Even pre-1914-war polar exploration was not really dangerous compared with civilised life. But scurvy was a major hazard, and winter sledging could be very uncomfortable indeed. I have left winter quarters for cold-weather sledging with a sleeping bag weighing 12 lb. and returned with the same bag 28 lb. in weight. All the extra weight was frozen breath and sweat that had to be thawed out and warmed before I could sleep. In 1907–12 we were strictly geared to the polar quest. One gallon of oil had to last four men for a week, or three men for ten days. Not a drop could be spared from its primary task of preparing hot meals. In 1926 or thereabouts a very remarkable generation of Arctic explorers arose in Cambridge. They evolved an efficient technique of living on the land, and, in kayaks, out-Eskimoed the Eskimos. Gino Watkins and his colleagues did more than any other factor to rehabilitate British polar exploration in Scandinavian countries when our reputation had slumped through Amundsen's easy victory in the polar quest. In 1934 these men transferred their attention to Antarctica as the British Graham Land Expedition under John Rymill. The menace of scurvy had gone (except under catastrophic circumstances) with the availability of potted vitamin C and the rational use of what meat the Antarctic can provide—which on the coastline is a great deal. Winter travel had been made comparatively comfortable by a

FIG. 4. *1935. Motor transport.* By this time motor transport had developed sufficiently to be used as a routine by Admiral Byrd's Antarctic Expedition. A tractor train is seen leaving from West Base to lay depôts in the Rockefeller Mountains. Note the extra-width tank treads, designed by Army engineers to facilitate travel across the surface. (*U.S. Navy photograph.*)

FIG. 5. *1935. Air transport.* By this time aircraft had also become a useful method of transportation. A small biplane from West Base brings supplies to a biological field party 240 miles away at Mt. Grace McKinley to replenish supplies. (*U.S. Navy photograph.*)

doubling of the oil ration; a simple but fundamental change from which, however, the early man-hauling poleseekers were inhibited by the nature of their tasks. From Rymill's generation in direct descent, stem the early leaders of the Falkland Islands Dependencies Survey, that unrivalled British nursery of dog-sledging technique, though the Australians are hard on our heels.

THE 1939–45 WAR

The 1939–45 war was truly global and total, and for some years the Antarctic was deserted as never before in this century. German raiders used sub-Antarctic bases as supply depôts and boltholes in their raids on Allied shipping and the whaling fleets. In 1938 the Reich had sent a catapult ship carrying two flying-boats to Antarctica to stake a claim and spy out the land. Later raids underlined the rather sinister emergence of politics and national ambition as motives in the Antarctic exploration field. It was a variant on an old theme. Iceland and Greenland in the 10th century owed their exploration and settlement not least to the fact that Eric the Red and his turbulent fellow Vikings could not bring themselves to refrain from homicide. The difference is one of scale rather than of type. The raider *Kismet* sank nine ships totalling 57,000 tons, the *Pingouin* sank 136,000 tons of Allied shipping and captured a whaling fleet with 22,000 tons of oil.

In 1939–40 the United States staged a major expedition which had the distinction of embracing for the first time both East and West Antarctica, bases being established both at Little America and at Marguerite Bay in what we call Graham Land and the Americans Palmer Land, a clash of nomenclature that reflects a controversy a century old. In 1944–5, when the Allies' naval supremacy was re-established and the sea war over, a naval expedition under Commander Marr—who

first went south as a sea-scout under Shackleton—was sent to West Antarctica, and the Falkland Islands garrison was strongly reinforced. Landings were made at Deception Island and Port Lockroy and the Melchior Islands, and the Falkland Islands Dependencies Survey began to take shape.

A new factor in Antarctica had emerged; Argentina and Chile were looking to the south. Is it unreasonable to infer that they had decided (wrongly) who would win the war and had determined, not unnaturally, to pick up what they could of the geographical loot that might be lying about when the British Commonwealth and Empire had been destroyed? Argentina, at least, had some claims to succession, though not to usurpation when the elimination of the present occupier did not in fact take place.

THE POST-WAR YEARS

When we study the history of Antarctic exploration from the end of the 1939–45 war the pattern becomes more complex. As man's mastery of machines progresses and his movements become more rapid, the earth, considered in terms of time taken to traverse it, shrinks. This fact makes international organisation and international understanding more imperative year by year.

At the same time the course of recent events has encouraged an aggressive nationalism which is rapidly bringing about the splintering of the old colonial empires and the emergence of new States, inexperienced and prickly, eager to assert their new-gained rights and to enlarge their realms. This dichotomy is mirrored in the Antarctic history of the last ten years. The year 1948, for example, saw the conception of the first truly international Antarctic expedition. On the initiative of Norway, the Norwegian-Swedish-British Expedition of 1949–52 was launched with purely scientific objectives. Two years of first-class scientific work was done in amity by a truly international team who emerged from the experience with enhanced mutual respect and a record of work of unsurpassed value. The inland ice of Queen Maud Land was investigated to a depth of 100 metres by platinum resistance thermometers and a core taken down to 200 metres. Six hundred and fifty successful radio-sonde ascents were made up to a maximum of 72,000 feet. A seismic profile of the inland ice was accomplished during a penetration inland of 390 miles. Aeroplanes of the Norwegian and Swedish air forces combined to extend a survey well begun by the expedition's weasel and dog-sledging parties. Organisation was efficient and the work done in comfort, as when my friend G. de Q. Robin lived for several months on the plateau in a caravan fitted up as seismic laboratory and living quarters combined, much as if he were on a vacation tour at home. But even today exploration is not without its risks and three men lost their lives when their vehicle plunged into the sea over the coastal ice-cliff during a dense fog.

But competition is more common than co-operation. In West Antarctica, Britain was faced with claims both by Argentina and Chile, not only to that sector of the continent, but to the off-lying islands and the Falkland Islands as well. By 1945 the South American neutrals had tabled claims to all land to the south of that continent: claims that were based partly on geographical propinquity, partly as successor States to Portugal and Spain: as inheritors of pretensions that stem from the Treaty of Tordesillas in 1494 and the Papal Bull upon which that Treaty was based.

Twisting the lion's tail is today a safer occupation than it was a century ago. Yet this country has reacted vigorously enough, through occupation and administration, upon a major scale. The Falkland Islands Dependencies Survey is a name that stands for an effort in Antarctic activity that is, in its way, unique. Since 1944 this activity has been maintained on a steadily increasing scale. Today Britain has ten permanent bases in West Antarctica with a magistrate and supporting team at each. From those on the mainland the old Watkins-Rymill tradition of dog-sledging has been maintained and improved, journeys running into thousands of miles having been made.

The bases breed their own dogs and carry out continuous trials of equipment and rations. In fact an experimental laboratory in methods of polar travel has been in existence there for a dozen years. A very complete meteorological record is kept at all stations for the benefit of the whaling industry from which, until recently, the costs of occupation were mainly defrayed. At some stations an ionospheric and seismological programme is in full swing. Topographical and geological survey are major objectives and this year a start has been made on an aerial survey of the whole region in dispute.

Side by side with the British bases, sometimes within a few hundred yards, stand those of Argentina and Chile, manned chiefly by Service personnel. Chancelleries propose—or refuse—arbitration through the International Court. Formal protests are bandied to and fro. Through it all, with occasional exceptions when national fervour outruns good sense, the personnel of the expeditions afford each other mutual help. Straying Argentine St Bernards are returned by British scientists: British invalids are cured by Argentine doctors and vice versa.

In 1948 the United States made a proposal to seven governments for a limited kind of condominium control. From time to time one nation or another formally reserves its rights. The suggestion of United Nations control finds increasing favour in many quarters and has been mooted in the British Parliament. In the meantime the situation is bound to have its effect on polar achievement in many ways. It greatly increases the amount of money, manpower, and energy expended upon the opening up of the Southern Continent. If, for example, Russia gazes polewards, the United States must, too. The strategic value of Antarctica, should atomic war break out, with the consequent likelihood of the destruction of the Suez and Panama Canals, will stem from the fact that all inter-continental seaborne traffic, and much coastal traffic, must proceed via the Cape of Good Hope and Cape Horn. Antarctic

exploration and exploitation is bound, therefore, to become more and more an affair of governments rather than of individual adventurers or scientific societies. At the same time less and less scientific results will accrue per unit of energy and money expended. A failure to work up and publish results is, indeed, a characteristic of recent Antarctic exploration and one to which the British Association, as other science associations, might well give heed.

Since the war the Americans have planned and carried through operations almost on a war scale. Admiral Byrd goes south periodically with many ships and thousands of officers and men. In 1948, for instance, planes from the deck of an aircraft carrier, standing off the coast, reconnoitred some 800,000 square miles in a few weeks. Airborne magnetometers were used for the detection of islands completely hidden by land ice. Icebreakers steamed in a matter of days half-way round Antarctica from the Ross to the Weddell Sea and, incidentally, pulled out Finn Ronne's party which had done a unique job of dog-air co-operation with the British under Butler along the Graham Land coast. This American party made history by over-wintering two women at their base.

The contribution of Australia, with the veteran Douglas Mawson as the main driving force, and of France, have been outstanding. In Kerguelen, France has a sub-Antarctic scientific outpost of first-class quality and is preparing airstrips there 3000 metres and 2000 metres long. An intriguing side issue is the attempt to acclimatise "reindeer, mink, sheep, pigs, and ponies". From a base in Adélie Land the French have explored widely along the coast and some distance inland. Australia has permanent stations established at Heard Island and at Mawson on the mainland.

WHALING

No account of 20th-century Man's relationship to Antarctica would be complete without some reference to the history of the whaling industry. Whatever may happen in the future, so far whales, elephant seals, and fur seals are the only tangible assets Antarctic exploration has produced.

The first shore-based venture in South Georgia in 1904 employed one catcher and took 195 whales In 1954–5 nineteen factory ships, three shore stations, and 254 whale catchers between them accounted for 37,654 whales and produced 372,956 tons of oil and nearly 80,000 tons of meat products.

The whaling industry has not been without its vicissitudes. The price of oil has fluctuated from £8 10*s*. a ton to £170 a ton, though it is now fairly stable at £75. But operating costs increase steadily and today the margin of profit has become very small. The success of whaling, of course, even if prices are remunerative, must depend upon the maintenance of the stock of whales, and this has led to international regulation on a considerable scale. In the early days the industry was carried on from shore stations, all of which were, in those less complicated times, in the undisputed control of Britain. The industry was easily controlled by the issue of licences. In 1925 the situation was transformed by the invention of the floating factory, and the stern slipway followed soon. The whales could be hauled by winches and flensed and rendered down on board, thus doing away with the need for a shore base away from the home country. From now on an entirely different type of control was needed. In 1931 the League of Nations drew up a Convention which established the principle of the international regulation of whaling on the high seas. In 1933 most companies agreed to voluntary limitation of catches. Whaling inspectors were appointed to accompany all ships in 1934–5. Complication was caused by the defection of Germany and Japan from the League before the 1939–45 war, but when this was over the International Whaling Commission was established in 1946. The catch is now limited to 15,000 Blue Whale Units. Despite protective measures the Blue Whale stock has greatly decreased and there are today signs that the Fin Whale stock, now the mainstay of the industry, is on the decline.

The skill of the whalemen of Norway has been both the strength of, and a danger to, the whaling industry. Something in the nature of a Guild of Whalemen has developed with its accompaniment of a jealously guarded monopoly of skill. The two chief trends of the half-century have been the improvement of the technique of whaling and the more efficient utilisation of the body of the whale. In the former field Norwegians have been supreme, though recently useful innovations such as the electric harpoon, to replace the destructive harpoon gun, and the echo whalefinder, have originated in this country. Other notable developments have been the use of helicopters for finding whales and the attachment to whale carcasses of small wireless transmitters so that catchers fitted with direction-finding apparatus can home on them in any weather conditions. In utilisation Britain has, perhaps, taken the lead. Today almost every part of the whale is used. The main use of whale oil is, of course, in the manufacture of margarine and soap, but it is also sold as burning oil, for tempering steel, for leather dressing, and in lubricants. Experiments in the production of artificial wool from blubber are under way in Japan. Whale meat meal is used for feeding cattle, pigs, poultry, and silver foxes: small quantities of whalebone for the grooving of sliding doors, for collar studs and stiffeners, for cigarette cases and the backs of hairbrushes. Canned whale meat is today, even in peace time, in some countries a common form of human food. In 1954 30,000 tons of salted whale meat were used as food for miners in Japan alone. In 1954–5 these by-products were worth nearly a million pounds.

Whaling springs from exploration, but it has, in its turn, had a profound influence upon exploration. Here again, there has been a mixture of effects. Whaling captains are, not unnaturally, loth to give away the location of good hunting grounds. This trait must have had its effect upon the bitter and frequent controversies about priority of claim. Yet there have been from time to time enlightened owners and skippers who have contributed to the unveiling of the southern continent and the islands off its coast: notably the Enderby Bros, John

Biscoe, and Weddell. In the present century the firm of Salvesen, Captain Larsen (who died while whaling in the Ross Sea), Lars Christiansen, and Mikhelsen, deserve to be remembered as explorers as well as whalers.

Another valuable contribution to the exploration of Antarctic seas that springs directly from whaling is the oceanographical research carried out by the Royal Research Ships *Discovery I* and *II*, and now continued by the National Institute of Oceanography. This work was originally financed by the United Kingdom from whaling dues. The *Discovery*'s work is essentially a survey of the Antarctic seas and their organic resources. These seas have an exceptional density of marine life, and oceanographical conditions are distributed in a simpler pattern than in most other oceans. For twelve years between the wars RRS *Discovery* covered the southern charts with a complex network of courses, encircling the globe. The scientific results surpass even those of the *Challenger*. By 1938, eighty memoirs by fifty authors filled fourteen volumes. More than 4000 whales had been marked. Her researches on the breeding and life-cycle, the distribution, migrations, and habits of the whale have been of major importance to the successive bodies responsible for the regulation of the industry. The oceanographic survey has revealed the broad structure and mechanics of the principal water masses and currents and certain basic features of the distribution of the ocean plankton.

THE FUTURE

Who can predict what may happen in a similar tale of years in the future? Antarctica may be colonised: Man may have landed on the moon. On the other hand, it is as likely that, if Man's passions get out of hand—and control of emotions is not a notable 20th-century trait—the survivors of mankind may be plunged into a Dark Age such as has succeeded civilisations of the past at least nine times in the chequered history of mankind. Man is indeed at a crossroads today, and we of the British Association may well ask ourselves what we can do to help the world to make the choice that will ensure

FIG. 6. *February 1956. Sno-Cat and Auster on skis, at Shackleton.* Greater comfort and higher travelling speeds are obtained by using Sno-Cats. With an aluminium body and a load capacity of 2300 lb., they have proved useful under Arctic conditions and will be used by the Trans-Antarctic Expedition led by Dr V. Fuchs to cross the Antarctic Continent. Fully loaded they are expected to run $1\frac{1}{2}$ miles to the gallon of fuel. (*Photo by the Trans-Antarctic Expedition.*)

the survival and further progress of humanity perhaps to the point when Man is no longer earth-bound.

So far as the future of Antarctica is concerned, we still have too little to go upon. Now that atomic energy is available and atomic power is immediately ahead, the mere strategic threat of a monopoly of Antarctica by any one power should by itself suffice to keep the interest of the nations alive. Great and valuable mineral deposits there must be in any continent of this size and kind. Nothing of significance has yet been found. Prospecting on the continental scale, let alone exploitation, will be so costly that, apart from a stroke of luck, it will require finance and organisation at least on the national scale to ensure success. In 1951 the £200 million Kitimat project was started in a completely undeveloped area in British Columbia and is just about to pay off. But this is based on cheap local power and will be used to process aluminium ore brought 4500 miles from Jamaica. In Antarctica something on this scale would be the least that would be required should large and valuable ore bodies be found. Airborne magnetometers and stereoscopic camera mapping are already in use in Antarctic surveying. Future exploitation lies with the co-ordinated use of airborne surveyors carrying out wide sweeps and of helicopter-borne ground parties equipped for high-speed core drilling and rock sampling. In Canada two helicopters and five geologists have prospected in one season some 67,000 square miles. Attention must be concentrated on the relatively few exposed rock surfaces where mining could be carried out without difficulties arising from ice movements. Once the ore is located the whole enterprise could gradually go underground. Tunnel or adit entry might be followed by the construction of underground engine rooms, hoisting gear, and mineral dressing plants. Floating power stations that could be withdrawn for maintenance during the "closed" season might be a useful expedient in the initial stages, but land-based stations would be essential to any permanent settlement.

It has been suggested, for example, that the Antarctic might have a future use as a vermin-free store for the world's periodical food surpluses; here they might be preserved against the needs of future generations when widespread crop failures might otherwise spell disaster to a world whose population seems destined to increase. Again, one of the main claims for atomic power is that it can be maintained for long periods in remote places with a minimum of attention and thus might be used for the development of the desert areas of the world, uninhabited today because they are too cold, too hot, or too dry. If atomic-powered icebreakers, why not atomic-powered settlements on the Antarctic mainland? The harnessing of the Antarctic gales is another possible source of power. But everything will depend upon the discovery of a worth-while economic objective which is not at the moment in sight. The chances are that, for the remainder of this century Antarctica will remain the scene of investigations in pure rather than applied science. But Man may yet find a way to release the latent heat of ice and add a seventh habitable continent to the six he already has in thrall.

SCIENCE AND LEARNING IN GERMANY

J. HORNE

The University of Birmingham

The disaster which befell the German universities and other centres of research and learning (academies, libraries, etc.) under the Nazi régime dates back farther than the physical destruction by enemy action. True, of the thirty-one universities alone, only Heidelberg, Tübingen, and Göttingen were spared complete destruction. Libraries fared no better: thirty-two university libraries lost 4·2 million volumes (just under a third of the total university book stock), some of these being irretrievable treasures.

German scholars reckon the ruin of their disciplines from the days when the power of the Nazis took away that lifeblood of genuine search for truth and freedom. Prof. Lilge of Harvard,* and many other scholars the world over (including the German Federal President, and, in the east, the President of the Democratic Republic) have spoken of how the exodus or expulsion of over 1000 scholars and scientists impoverished German university work and life. The losses in terms of potential advancement went far beyond the toll taken by the rearming Third Reich, and far beyond the diminished opportunities due to the war itself.

Germany, already lagging behind before 1939, was hopelessly outdistanced in many fields of science during the international "blockade" of the war and during the later widespread destruction.

PEACE

The year 1945 brought a precarious, hungry, unsettled peace. German universities such as Prague (the oldest of the German universities, dating from the 14th century), Breslau, and Posen were lost for good. Politically, a whole bankrupt generation of university teachers who had made their peace with the Third Reich (many of them highly jubilant at Hitler's ascendancy) was now proscribed, and only gradually were the universities opened up again, under academic control officers who did their best to exclude ex-Nazis from professorial posts. It was not until the establishment of a German Government (in 1949) that a more tolerant policy as regards the reinstatement of ex-Nazi professors was adopted. Their appointments were in all cases still subject to confirmation by the occupying powers. The great powers, especially the U.S.A. and U.S.S.R., were eager to get all the scientific benefits extractable from a defeated Germany, and induced or invited many specialists in the sciences (especially technologists) to work abroad, in their own countries and in modern institutes. Many scholars had good reason to flee to the West, where they found political sanctum. In many cases a chair was soon found or specially founded for them.

In the West alone, two new full universities were opened: The "Free" in West Berlin where the former Technische Hochschule was renamed "Technische University", to express the desire for a more "universal" education of the science or technology student; and at Mainz, where a medieval theological university had been in existence till Napoleon abolished it in 1809. It was the French occupation authorities at Mainz who re-created this university, now named after the great son of the city, Gutenberg, the inventor of the mobile-letterpress.

It would be futile to pretend that no ex-Nazi professor holds a teaching appointment today. German economic recovery has further aided a comeback of reactionary forces; but on the whole academic staffs today are hard-working, businesslike and, officially, non-political. A new and more democratic spirit showed itself last year, when the Professors at Göttingen (today the leading centre of research and scholarship) led a strike against their highly incriminated right-wing minister of education!

Much has happened since the early days of reconstruction, when students crowded into requisitioned machine halls and hangars, when papers and pencils were scarce, and when a warm, light room to study in was at a premium. Generous help has come from abroad and from German industry. Aided by its "Association for the Promotion of Science and Learning" (Stifterverband) the German Research League (Forschungsgemeinschaft), composed of members of universities, embarked on a policy of energetic rebuilding on an impressively broad front. Seven years of reconstruction have brought remarkable results. Up-to-date laboratories and lecture halls (often named after their benefactors, such as at Hanover), and fine architecture and furniture now stand beside neatly piled ruins, grim mementoes from the past.

STUDENT NUMBERS AND INCOMES

Student numbers have risen rapidly and the old custom of "student migration" returned. This means that a student can, with very little formality, change universities, spending one year here, the second there, till he ends up writing his thesis in a third. Table I illustrates the great revival of universities and of Technische Hochschulen.

TABLE I

Term	*No. of Inst.*	*Universities*	*Students enrolled*		
			Technische Hochschulen	*Others*	*Totals*
Winter 1948–9	60	72,028	19,920	13,521	105,469
„ 1952–3	65	75,803	27,116	11,035	113,954
„ 1953–4	65	77,067	27,884	10,713	115,664
„ 1954–5	64	81,424	28,636	10,749	120,809

(Source: Federal Office of Statistics, Wiesbaden)

* "The Abuse of Learning", 1951, Oxford University Press.

The corresponding number of academic teachers for 1952 were: Heads of Departments, 2031; Honorary Professors, 446; Senior Lecturers (title Prof.) 632; Assistants (Lecturers), 940; others, 1941; total, 5990.

A forward-looking federal policy of student grants is, however, needed; and the availability of British grants is envied today by German students and staffs.

The minimum a German student could exist on, is estimated today to be a monthly sum of DM150 (approx. £22). The average for 1953, spent on maintenance, books, without fees, is in fact far below that sum (Table II).

TABLE II

	Male	*Female*	*Total*
No income at all	7·85%	14·4%	11·13%
Up to DM50	20·9%	20·6%	20·75%
Up to DM100	47·4%	43·8%	45·6%
Up to DM150	18·2%	16·9%	17·55%
Over DM150	5·65%	4·3%	4·97%

These figures have to be examined against two facts: (1) The German student is perfectly entitled to take a full-time job while enrolled as an undergraduate; (2) Many (? 50%) students whose homes and families are in Eastern Germany, study in Western universities or Technischen Hochschulen.

These eight Institutes of Technology are equivalent to universities in status, degree-value, and social standing (especially in an age of urgent technical reconstruction and rapid progress). It is interesting to note that, in apparent discrepancy to Britain, only 4% of students come from working-class homes, the bulk being the sons and daughters of the lower middle classes. Most professors still belong to the "upper" classes.

The financial difficulties do not greatly deter students, and it is always encouraging to find how impervious to poverty German students are.

RESEARCH

Research is not confined to the modernised institutes of university departments. There are four well-endowed scientific academies (the latest founded at Mainz in 1949). Outside the universities, the great Max Planck Institutes (succeeding the Kaiser Wilhelm Institutes) comprise a total of over forty research institutes, now dispersed over the territory of the Federal Republic. Göttingen has replaced Berlin as the centre.

The Länder (highest educational authority) are giving considerable financial support. The Deutsche Forschungsgemeinschaft (Research League) administers and dispenses research funds, and so can introduce an element of centralisation into an otherwise wildly scattered and unwieldy mass of research projects.

Industrial research is sponsored by industry itself in its own laboratories, and also in university precincts. Smaller firms can derive joint or separate benefit from contributions to the upkeep of the Batelle Institute (1953) at Frankfurt where sponsored projects are studied, as in the like-named Institute at Columbus, Ohio, which served as a pattern for that at Frankfurt and the slightly older one at Geneva.

A quotation from a German reference book* shows the spirit which today pervades research and university work in Germany, a country which devotes over half a milliard DM (including West Berlin) to research:

> Even today not all difficulties have been overcome and although the majority of research institutes are in working order the amounts of money which they have at their disposal have not kept pace with the new and increased demands made upon them. It is for this reason that anxiety is felt for the preservation of a body of young, well-qualified scientists to fill the ranks of German scientific researchers.

Today the German world of learning can boast of Heidegger in philosophy; Stammler, Otto, Müller, and many more in philology; Rohrbach in mathematics. An enlightened, objective, and totally unchauvinist school of historians are pupils of Meinecke. Books have been published containing a national self-indictment of the universities and scholars; they are candid and touching in their sincerity. Most typical of the resilience of the German intellect is its capacity for drawing a hard-and-fast line. The year 1945 is called Zero (beginning, not nihilism), and a "clean sheet" starts there. It looks as if it will be clean for some time.

* Germany Reports, Press Information Office, Federal Government, Bonn, 1955.

TWENTY-FIVE YEARS AGO

(*From* DISCOVERY, *December 1931*)

In September 1931 the British Association celebrated its centenary in London. The President was General Smuts. Under "Notes of the Month" appeared the following:

"Since its foundation in 1920 the aims of DISCOVERY have been similar to those of the [British] Association, with the result that some of its contributors have spoken at every meeting during this period. The present meeting will be no exception. Two of the sectional presidents are members of our Committee—Sir J. J. Thomson (Mathematics and Physics), who is also our Senior Trustee; and Prof. C. S. Myers (Psychology). Many subjects in the programme have been dealt with in this journal recently. For example, 'Insects and Man' (Zoology) was discussed by Prof. Julian Huxley with reference to ants, while 'The Distribution of Plants' (Botany) has been the theme of several articles by Prof. Seward. [Another trustee of DISCOVERY.] 'Broadcasting and Education', a subject for discussion appropriately chosen by the Educational Science Section, will interest readers who remember the articles which Mr Edward Liveing wrote for DISCOVERY not long after the BBC was founded [1927]. Many of his predictions have come true, and already the new headquarters of the BBC are nearing completion. The British Association has, as usual, arranged a series of Evening Discourses, and Sir Oliver Lodge is sure to attract a big audience for his 'Retrospect of Wireless Communication'."

LETTERS TO THE EDITOR

"To See Ourselves As Others See Us"

Sir:

As the only way of getting more scientists in the future seems to be to divert arts students from their original pursuits, I thought it might be of interest to your readers if I briefly described what the world of science looks like to an arts graduate who has already been impelled into it by economic circumstances. And since to the humanist any "world" means the people taking part in it, I would like to draw a picture of scientists as seen in their natural habitat. This amateur sociological survey, by the way, has been undertaken in one of our largest research organisations which concentrates on development work with a fairly generous allowance of fundamental research.

What first struck me was how different the scientist's stereotype—that picture of the scientist which the public carries in its mind as the type—is from the real thing. The typical scientist is thought to be rational, intelligent, basing his action on logic and forsaking emotion, interested in the pursuit of truth for its own sake, sinking his own interests in the love of the work, and accepting no outside authority. True, there is a superficial resemblance to this portrait, but it did not need long among the scientists in their laboratories to discover that human nature is the same all the world over, and that the strenuous efforts of scientists to approximate to this ideal have resulted in the oddest compensatory quirks being incorporated in the scientific character. In fact, far from the scientist being a model of logical behaviour he is full of the most contradictory and paradoxical qualities.

This is not an original discovery on my part. Indeed, I was startled to find how readily senior science administrators agreed that it is a commonplace situation for a specialist scientist to keep his logic for his specialisation and not carry it over into personal or social situations. They consider this an amiable weakness, but to someone trained in the humanities it indicates a major failing both in the educational methods followed and in the man's own attempt to integrate his own experience of life. As a result he is not always easy to get on with, however patient and long-suffering he may seem, as his actions are not necessarily related in any predictable way to his stated beliefs.

Another paradox of the scientist's behaviour is that as a species he does more writing than any other form of life (even possibly including journalists), but manages to do it more badly than anyone else. Apparently he finds it hard to learn from experience, but if one could present him with rules of style founded on statistical averages he might manage to apply them. (If you doubt my statement about the amount of writing he does, consider the year's output of scientific papers in relation to the number of scientists and think what would happen if, say, railway officials or even lawyers published so extensively.) The real paradox about scientists' writing is that it is intended to be a communication of their results, but that the spirit in which this "communication" is made approximates more to the "art for art's sake" school of writing than anything we have yet managed to introduce on the arts side. The scientist plainly does his writing as a matter of self-expression, and does not care two hoots whether anyone else (bar the referee) understands him at all. To anyone brought up on the arts side where we are taught to believe that style is an indication of character, the amount of shockingly bad writing that goes through on the science side is frankly terrifying, both in itself as communication, and in the inferences we draw as to the type of civilisation we are rushing towards. Fortunately the engagingly simple way in which the scientist so often states the obvious leads us to think life may not be too bad under the new dispensation.

Then there is the myth about not accepting authority. The whole of the scientist's work is built up on authority —provided it is the authority of an earlier specialist. If a true statement is made by a non-specialist it does not count as evidence. On the other hand, there is the absurd situation that frequently not even the most matter-of-fact statement can be made unless a reference is first found for it. In fact, the scientist relies just as much as anyone else on authority, but he has his own peculiar way of selecting his authorities—and not necessarily always a better or more effective way. To us on the arts side one of our staggering revelations comes when we watch the scientist unable to find any other authority to quote at the end of his new papers but himself. To us this method of invoking one's own authority seems arrogant, though no doubt to the scientist it seems quietly modest.

Another instance of apparent arrogance is the scientist's conviction that he is able to do everybody else's job better than they can do it themselves. In fact, one of the reasons why the scientist is such a bad administrator is that he cannot accept the fact that other people know more about their own jobs than he does and learn how to make use of this fact. He will permit specialisation to other scientists, but is an incurable believer in amateurism for everybody else.

This is the most disturbing fact about the scientist as a fellow-worker; he cannot use his scientific method to analyse the functions of the work to be done and see that these are done by specialists—from other disciplines if necessary. Moreover he constantly mistakes knowledge for wisdom, and doesn't see, as even arts graduates do, that there are no doctorates in wisdom. As we used to say *Experientia docet*—and we didn't translate the noun as "experiments".

I have no doubt that experience will show that it is a good thing for people trained in the arts to move over to the sciences, but heaven help us if there is ever a great demand for the reverse process!

Yours truly,
CLARE FRY

Shortage of Scientists

Sir:

In view of the scarcity of technicians and scientists, I would like to draw attention to a small group of people who might supply a fractional part of the deficiency. These are people in the age groups above that of university leavers. They have attained national certificates by their own exertions, but because of failure in health or other difficulties they have been unable to continue their studies. With a little help from the State they might be able to do so. Why should such people be left to pick up their academic training through technical schools attended after a tiring day's work?

F. ROY GREEN.

Aylestone, Leicester.

The Science of Science

Sir:

I was interested in your comments on "The Science of Science" (May, pp. 179–80). I have found an understanding of the logical basis of research to be a very great help to me, especially an awareness of the validity of conclusions from the various forms of deduction, and of the limitations of inductive conclusions. I think this is the main *practical* use of this subject both in planning research and in considering critically the work of others.

The main drawback to the present situation at Cambridge is that the History and Philosophy of Science courses are (*a*) optional and (*b*) orginised to be particularly closely tied up with the Physics course. The first fact gives, presumably unintentionally, the impression that knowledge of the subject is a slightly unnecessary luxury which may or may not be studied as one pleases, and the second rather reduces the value of the course for the many non-physicists present.

I think the idea of a separate course as at Cambridge, is fundamentally a bad one, and I would much prefer to see an awareness of logical limitations and the historical approach made an integral part of lectures on *all* subjects.

This would doubtless mean that fewer *facts* could be dispensed during lectures, but far too much lecture time is already taken up by the repetition of facts which students could easily find in

textbooks. It would be a very good thing if lecturers concentrated more on exhibiting and encouraging a critical attitude to the logical and technical methods by which "facts" are ascertained, and on expounding the concepts by which facts are interrelated in the various disciplines of science. Correspondingly, examination questions should be phrased so as to bring out the ability to criticise scientific conclusions and to discuss ideas using a few facts in quoting examples, rather than to allow or even encourage the regurgitation of facts which may or may not be properly understood, as they often do.

If this were the case the teaching of science would be more likely to be efficient in that it would not be pumping facts into people, but inculcating an attitude of mind which is absolutely necessary for first-rate scientific research and most useful in other walks of life.

I have been interested to notice recently that this seems to be the teaching attitude at the University College of North Staffordshire (*Observer*, July 1, 1956, p. 7) and also the way in which Scottish students have recommended a university should be run (*Times*, July 6, 1956, p. 5).

C. D. PUTNAM, M.A., F.R.E.S.
Halstead, Essex.

[Since writing the above I have read a most interesting article by Prof. G. W. Pickering (*British Medical Journal*, No. 4985 (July 21, 1956), pp. 113–16), who advocates a similar approach in courses for medical undergraduates, and who ends with this very apposite quotation from Karl Pearson: "The true aim of the teacher should be to impart an appreciation of method rather than a knowledge of facts."—C.D.P.]

Entomological Photography

Sir:

In the note commenting on M. de Cuziat's excellent pictures of a desert locust in the July issue of DISCOVERY, p. 266, I was surprised to read that "photographs of this nature are notoriously difficult to take as frequently the requirements of lighting cause the object to be overheated". No such difficulty, in fact, need arise. Electronic flash is the ideal system of lighting in entomological photography, and from the appearance of M. de Cuziat's photographs, I should say that this system was employed. Even where electronic flash is not available, overheating of the subject can be easily avoided by the simple expedient of placing a sheet of glass between the light source and the subject, changing it at intervals if necessary.

The principal difficulty in this field of photography lies in the very narrow depth of field resulting from the use of extension tubes. Active insects must somehow be confined to very narrow spatial limits, and the use of anaesthetics or refrigeration for this purpose has an unhappy effect on the animal's posture. In the case of M. de Cuziat's moulting locust, however, it is unlikely that this difficulty would have arisen, for the animal would have shown little if any inclination to move from its position until the moult was completed.

I should be most grateful and pleased if any of your readers have suggestions to make on the restraint of small invertebrates that are required for photography.

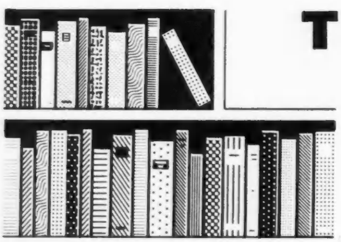
HARRY MILLER.
Flat 3, 24 Claremont Road, London N.6.

(Unfortunately full technical details of the locust photographs were not available at the time of publication. —Editor.)

Sir:

The excellent photographs of a locust moulting in your July issue represents not the Desert, but the Migratory Locust (*Locusta migratoria* L.). A correction may be welcome to some readers.

B. P. UVAROV, C.M.G., D.Sc., F.R.S.
Anti-Locust Research Centre, London.



THE BOOKSHELF

Biographical Memoirs of Fellows of the Royal Society

(*London, 1955, 263 pp., 30s.+1s. postage.*)

As a rule it is difficult to review the first issue of a new journal because the content of that issue may give no indication of the final pattern. This new journal is, however, unmistakably the well-known "Obituary Notices of Fellows of the Royal Society" with a new title. The change seems a mistake. First because it is misleading unless notes on still living fellows, or on those long dead, are to be included. Secondly it is mealy-mouthed. Members of the French Academy are often referred to as "the immortals". This claim is not even made metaphorically for an F.R.S. We die, and might as well go on having obituaries.

The content, as might be expected, is varied; but it is so varied as to suggest that contributors are given little guidance on length, style, or standard. Of necessity, therefore, a reviewer compares the obituaries, looking for the characteristics that distinguish good from bad. An obituary should give the essential facts about family, education, and jobs; all those printed here do this. For this particular purpose there should be a complete bibliography of scientific papers and at least a partial bibliography of other writings; several of the obituaries are inadequate in this respect.

Other requirements are more matters of taste. *De mortuis nil nisi bonum* is all very well in some circumstances, but literal adherence to the injunction makes a dull and unconvincing obituary. It must be made clear that, in spite of a few defects, this was an able scientist, liked and respected by the writer. The writer need not always agree with his subject's extracurricular activities but Olympian sneers are out of place. On this count Sir Wilfred LeGros Clark's treatment of Wood Jones and Arthur Keith is criticisable though his account of their scientific work is admirable. Simple omission of non-scientific activities will not do for they must be known if a scientist's motives, even his scientific motives, are to be understood. The attitude of tolerant wonder that Prof. Newman adopts towards Alan Turing is probably as good a solution as any. An obituary is not like a book review; it is concerned with what a person was like rather than with what he ought to have been like.

Good obituaries are good for varied reasons; bad ones are generally bad because the subject appears colourless. Thus the eulogy that Lord Waverly and Sir Alexander Fleck compose on Sir Wallace Akers tells us little of the reason for his success in the presumably somewhat competitive environment of ICI. Similarly Dr K. M. Smith conveys little impression of the personality and intellectual exuberance of Redcliffe Salaman; his activities are catalogued rather than described.

Quality does not depend on the length of the obituary. There can be no standard, for lives vary in length and scientists fill them to varied extents. Sir George Thomson compresses an excellent portrait of G. F. C. Searle into a small space. But the editors of a journal like this should look critically at an obituary that only runs to four or five pages to see whether it is the subject who *was* unenterprising or the

writer who *is*. As a first step the attention of potential obituary writers might be called to a few recent outstandingly good obituaries, for example Sir Henry Dale on Edward Mellanby and Sir Edmund Whittaker on Albert Einstein. Unless they think it possible that they can approach that standard they should be asked not to accept the assignment. The number of possible writers is greater than is sometimes thought. It is essential that the writer should have liked and respected the subject; it is only convenient that he should also be an adept in the same field of work.

N. W. PIRIE

The Elementary Particles of Nature

Prepared by D. K. Butt, E. G. Michaelis, G. L. Miller, and P. T. Trent, Foreword by Prof. C. F. Powell (*London, Scientific Information Service, 1956, 19 pp., 7s. 6d.*)

The authors of this little booklet have tried to give a survey of the present state of our knowledge of the elementary particles of matter which will be intelligible to non-specialists and particularly to teachers in schools and colleges. The idea is an admirable one in view of the interest and excitement which the discovery of all these new forms of matter has evoked. The booklet itself takes the form of a collection of short articles which, after a Foreword by Prof. C. F. Powell, and a General Survey, describe in some detail what is known of the physical properties of each particle and of the interactions between them.

Unfortunately, the task is fraught with difficulties, and it is therefore not surprising if the presentation fails to be altogether consistent. Thus there enters on page six the anti-neutrino, in connexion with the Fermi theory of β-decay; but it is not until the next page that one gets any inkling of what might be meant by an antiparticle. There is, in fact, no simple statement offered in explanation of an antiparticle (which is, after all, one of the most important concepts of the subject) although after reading the whole booklet one does begin to get some idea. A serious defect is the complete omission of "parity", which is a property possessed by particles as definite as their spin or their charge. It is true that parity is not an easy concept to explain in straightforward language, being essentially a quantum mechanical feature, but an attempt would have been worth while especially in view of its importance in connexion with the K-mesons. One misleading feature also occurs. It would have helped considerably to understand the concept of spin had it been stated that this is analogous to the two independent states of polarisation of an electro-magnetic wave. The issue is further clouded by the statement that the spin of a photon has not been directly measured: it has, of course, since it manifests itself directly in the polarisation of gamma rays.

These criticisms are not minor ones; nevertheless, the authors are to be congratulated on having attempted a difficult task with no mean measure of success. It is hoped that their efforts will lead to an even greater general interest being shown in this most important branch of science. Several countries are in fact at present investing large capital sums to enable their scientists to build the accelerating machines which are necessary for the creation of fundamental particles in the laboratory.

B. H. FLOWERS

Atlantis—the Mystery Unravelled

By Jürgen Spanuth (*London, Arco Publishers Ltd, 1956, 207 pp., illus., 21s.*)

How gullible is Humanity! And Echo answers "How"! In the 4th century B.C., Plato in his "Dialogues" told a parable intended to show that a small virtuous Greek state (i.e. Athens) had in the past been able to defeat a luxurious "Great Power"—a Utopia state which was named "Atlantis" and lay beyond the Pillars of Hercules (the Straits of Gibraltar). Plato intended to be believed, and he adorned his description of the island of "Atlantis" with circumstantial details of its ships, armies, temples, etc., which would have sounded reasonable to his contemporaries. Finally, Plato tells, Atlantis was submerged by the sea.

Herr Spanuth now claims that it lies underwater off the island of Heligoland in the North Sea. The book is a translation from a German one. As long ago as 1675 a Swede named Rudbeck claimed that "Atlantis" had been in Sweden. Since then it has been assigned various homes, including Crete, Tunisia, and the Azores. Much time has been wasted in the fruitless pursuit of this mythical place. The usual recipe has been to take reputable archaeological facts and mash them with a thick sauce of wild hypotheses; the resulting mixture intoxicates the critical faculties. Herr Spanuth writes dogmatically that he has found "Atlantis"; his theories led him to the Nordic North, and when he arranged for some diving explorations off Heligoland, traces of stone foundations were found. There were walls, some reported by the diver to be 6 to 8 feet high and 36 feet wide. It is claimed that the wall structures stretched to a length of about half a mile.

This book claims to be a serious work, and so it must be prepared to be judged by the standards required and practised in modern systematic archaeology. Not the slightest evidence of date was found with any of these submerged "walls". They could not be photographed because the water was too cloudy. There is no plan of their general layout, but there is a choice photograph labelled "A square paving stone from Atlantis". There is no mention of the fact that remains of medieval villages, now submerged, are well known off the east coast of England. The author mentions but does not discuss the fact that the oldest map (1570) of Heligoland marks seven churches to the east which could be seen at lowest ebb. So far from having solved a problem, Herr Spanuth has barely begun the necessary work. In prehistory and in historic times, there was not *one* such localised submergence, but hundreds. In a recent book ("Myth or Legend", Bell, 1955) Dr. Glyn Daniel and I have mentioned some of the verified examples of prehistoric and Roman settlements below the present high-water mark in the Scilly Isles, Brittany, etc. All that is needed now at Heligoland is an unbiased investigation. Whatever is found it will certainly not be "Atlantis". Herr Spanuth's book deserves mention as a curiosity of modern times!

JOHN BRADFORD

Elizabethan Copper, the History of the Company of the Mines Royal 1568–1605

By M. B. Donald (*London, Pergamon Press, 1955, 405 pp., 60s.*)

The story of how copper production began in England might seem only a minor, though perhaps interesting, facet in our parochial history of technology. In fact it is a topic of the widest importance not merely to the history of technology, but also to economic, political, and legal history, in addition to the repercussions (hardly considered in this book) which copper manufacture eventually had on quite different branches of science and other technologies. Because of all these ramifications it would be easy for the economist reviewer to complain that this was really a book for the historian of science; for the scientist to complain that it is all politics. I am myself grateful that Prof. Donald has covered so fully all the most interesting and useful details of the creation and work of the Company of Mines Royal.

This company was the first to be formed in England for a purpose other than trading abroad, and it had a hard time establishing its legal position. The people concerned include many of the important persons of the Court but also a great many lesser characters who are now brought to life in the pages of this book. Scientists and workmen were imported from Germany to staff the mines and introduce the special techniques; they settled around the Cumberland mines and their words began to invade the English language. Such a term as "sagger" (whose maker's bottom-knocker is the delight of panel games) comes from the German's *saigern* or *seigern*, to melt.

The sections dealing with smelting techniques and the interesting appendix giving details of assay methods transcribed from Hochstetter's notebook are important. They would be improved if the author gave us information, based on modern measurements, about the

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composition of the local ores, the purity of the copper produced, and the accuracy of the assay methods employed. A more serious failing of this book is that although there is a long and detailed bibliography of books and MS sources divided under the several chapters, there is no indication in the text as to which particular source is being quoted or drawn on in any one place; this must make it difficult for anyone following in Prof. Donald's footsteps. It is some consolation to know that the greater part of the book is such a monumental and authoritative work that no such following will be necessary for quite a long time.

D. J. PRICE

The Penguin Story, 1935 to 1956

(London, Penguin Books, 1956, 124 pp., 1s.)

On their twenty-first birthday Penguin Books deserve a tribute from serious readers with slender pockets. Even those with ampler means owe them a debt, for Penguins have not only made already well-known books cheaply available; they have commissioned new books in intelligently planned series so that by now anyone with a few shillings a month to spend can become educated in subjects ranging from bacteriology to mathematics, archaeology to astronomy.

The first scientists to become Penguin authors were Julian Huxley, Fabre, Jeans, and Freud. The first commissioned books on scientific subjects were Kenneth Walker's "Human Physiology", "Bird Recognition" by James Fisher, "The Size of the Universe" by F. J. Hargreaves, and "Prehistoric Britain" by Jacquetta and Christopher Hawkes. Since these prewar days Penguin Books have continued to serve science well. J. B. S. Haldane, J. G. Crowther, J. W. N. Sullivan, A. N. Whitehead, Sir Arthur Eddington, C. H. Waddington, James Burnham, are names picked almost at random from the long list of successes. The series "New Biology" and "Science News" have been so ably edited that back numbers are usually hard to come by. Not least of Penguin achievements are the children's Puffin Books, fascinating introductions to pond life, trains and ships, printing, pottery, coal-mining, aeroplanes, stars, the human body, and many other aspects of the magical world of natural laws and man-made implements. They are all presented with the impeccable good taste so characteristic of these publishers.

"The Penguin Story" is a record of enterprise, forethought, and belief in the public these books have so well instructed and entertained. A generally literate community can be served by publishers in two ways: by a yellow press appealing to sensation, mass emotion, and the mental laziness which seizes on cheap slogans; and by responsible educators who believe that our innate curiosity and desire to learn can grow stronger if nourished. Penguin Books have served up such nourishment palatably to millions all over the world. They deserve their success.

I. NICHOLSON

Plastics in the Service of Man

By E. G. Couzens and V. E. Yarsley *(London, 1956, Penguin Books Limited, 315 pp., 3s. 6d.)*

This book is of a more specialised nature than its title might suggest; it is likely to prove more useful and interesting to the serious student than to the general reader, who will certainly find it heavy going, though not impossibly so. For the student, however, who has already sufficient knowledge to understand the numerous technical terms, the book is a mine of information.

There are very few questions which either serious students or interested laymen could ask about plastics which this book does not answer clearly and in sufficient detail for the needs of either. The nature of plastics, their methods of manufacture, their characteristic properties, their conversion into finished products, are all well described. Of particular value is the clear way in which the bewildering range of trade names for plastics is sorted out; the authors thread their way through this maze with the confidence that only comprehensive and authoritative knowledge can give.

With an expanding programme of technical education, books such as this—available at a price which the poorest student can afford—serve a very useful purpose, and it is to be hoped that the publishers will continue to provide works of a similar kind.

TREVOR I. WILLIAMS

Animals after Dark

By Maxwell Knight *(London, 1956, Routledge & Kegan Paul, 136+viii pp. 15s.*

Mr Knight has written a short book designed to interest amateur naturalists in observing animals at night. It was a good idea to include an introductory chapter on the senses of animals, although the information it contains is not always accurate. Most of the book consists of short chapters on the commoner British mammals, including bats, but there are two chapters on night birds and others on amphibians and reptiles, on fish, on insects, and on "other small game".

The best things in the book are the anecdotes based on observations made by the author (and the photographs, some of which are superb). There is, for example, a delightful and instructive account of an otter teaching its young to swim. The worst feature is the obscurantist attitude towards the attempt to describe animal behaviour scientifically. For Mr Knight, foxes are "cowardly" and "instinct tells" the "courageous badger" when to come out to feed. The many unsolved problems of animal behaviour are rightly given emphasis, including those which bear on the economic status of various species. Mr. Knight is anxious to persuade us, for instance, that the otter is a useful and not a harmful animal; his argument would have been strengthened by real evidence, or, if none exists, by a clear statement of the *sort* of evidence (including that derived from experiment) which could enable us to make a rational decision on this point. From this book it seems, alas, that Mr Knight would reject the necessity for such precision by calling it "the 'scientific approach', with all its graphs and tables, and what not". He asks that science should be used only for worthy ends, but does not seem to regard conveying accurate and reliable information as "worthy".

S. A. BARNETT

Creatures of the Deep Sea

By Klaus Günther and Kurt Deckert. Trans. E. W. Dickes *(London, Allen and Unwin, 1956, 222 pp., 18s.)*

Two heads are not always better than one, so far as the writing of books is concerned. But the authors of this book are experienced collaborators, their special study being the jaw mechanisms of deep-sea fishes. There can be no doubt that they have produced an admirably balanced account of deep-sea biology for that well-read person, the general reader. The book is copiously illustrated (there are 140 figures in 215 pages) and most of the drawings are well done. It was first published in Germany in 1950 under the title "Wunderwelt der Tiefsee". This English translation by Mr E. W. Dickes is both skilful and thoughtful.

After "Man and the deep sea" and a chapter on the main environmental features, the authors introduce the deep-sea fauna by way of a dive with Dr Beebe and Mr Barton in their bathysphere. Before dealing with the benthic and pelagic faunas they provide short chapters on food, inorganic substances, and the inhabited regions of the deep sea. The longest and most interesting chapter is on the biological peculiarities of deep-sea animals. Here Drs Günther and Deckert describe some of their researches on the mechanical working of the head in certain stomiatoid fishes. The two final chapters deal with the distribution, origin, and migrations of the deep-sea fauna.

Recent deep-sea research has already begun to change some of the conceptions that are considered in this book, which was written only six years ago. Observations from bathyscaphes have shown us that deep-sea oozes are firm rather than soft. The long, spidery legs of certain bottom-dwelling arthropods would not appear to be adaptations for walking on an almost liquid substratum. Again, the water near the deep-sea floor is not still, but there are appreciable currents, at least in some areas. The

geodetic spirals in the siliceous skeleton of the deep-sea sponge *Euplectella* have become more meaningful and we must think again about the size, form, and attachments of benthic animals. Perhaps the authors will be able to consider these aspects in a second edition. Meanwhile, those with a general interest in the ocean have this short but surprisingly comprehensive account of deep-sea biology. N. B. MARSHALL

Methods in Numerical Analysis

By K. J. Nielsen (*London, Macmillan Company of New York, 1956, 382 pp., 48s. 6d.*)

The revival of interest in numerical methods of stimulating the writing of books on numerical analysis. These books can be divided into three main categories. First, there are those which concentrate on one topic in the field, such as linear algebra, ordinary differential equations, or partial differential equations, and which treat the material in comprehensive detail. In the second category we have rather large books which attempt to cover several topics in numerical analysis in a non-elementary manner, written for the benefit of competent mathematicians. Finally, there are elementary books which are intended to serve as an introduction to the art and science of computation, written mainly for the beginner with restricted mathematical equipment. The book under review is in this last category.

The elementary book is the hardest to write, and involves difficult decisions regarding the choice of material. Shall the beginner be given a thorough grounding in computing principles, or shall he be introduced to the various techniques needed to solve problems? The nine chapter headings (Fundamentals, Finite differences, Interpolation, Differentiation and integration, Lagrangian formulas, Ordinary equations and systems, Differential and difference equations, Least squares and their application, Periodic and exponential functions) show that Dr Nielsen has made the second choice. Of the common problems in computing only the determination of latent roots and the solution of integral equations receive no mention at all.

The treatment is inevitably sketchy. For example, the chapter on finite differences contains no explicit mention of the desirability for differences to converge, and it is unfortunate that the first difference table has divergent differences as well as many numerical errors; operational methods are mentioned but not used. The chapter on interpolation, though giving the standard finite-difference formulae, makes no mention of the throw-back and modified differences, a common feature of modern tables. Crout's method only is given for solving linear algebraic equations and inverting matrices. The few pages on partial differential equations, which contain without definition words like "parabolic", "hyperbolic" and "boundary conditions", and a poor account of relaxation methods, might well have been omitted. There are many detailed proofs of formulae, involving simple but lengthy algebraic manipulation. Surely an elementary treatment need not lack elegance!

There are, however, some good things, notably in the sections on curve-fitting and data treatment, in the provision of remainder terms for most of the finite-difference processes, and in some of the computing hints. There is also a useful collection of tables of interpolation coefficients (Newton, Stirling, Everett, Bessel and Lagrange), Gauss quadrature coefficients, Lagrange coefficients for derivatives and integrals, powers and sums of powers, and tables to facilitate curve-fitting. Answers are given to examples included at the end of each chapter, and the text is illustrated periodically by worked examples. A short bibliography of books, tables, and articles is included for further reading.

Altogether, this is a brave attempt to achieve what this reviewer considers impossible of fulfilment, and the book will have most value when reinforced by expert supervision. L. FOX

Brief Notes

The work of the French Commissariat à l'Energie Atomique is set out in a beautifully illustrated booklet with fine colour illustrations, printed in English and available from the French Embassy, London, who can also supply bibliographical digests of French crystallography, mineralogy, and of French mathematics.

No. 3 (19) of the excellently illustrated magazine *Poland*, printed at Dom Stowa Polskiego, 11 Miedziana Street, Warsaw, contains an article on semi-conductors, a review of industry in Poland, and an article on "Treasures of the Earth" with a page of colour illustrations of mineral rocks.

China's scientific organisations are listed in a pamphlet obtainable from the Chinese Embassy, London.

A review of the work undertaken during 1955 by the National Research Council of Canada is published at 75 cents (NRC No. 3678) in Ottawa. This, and also the Canadian Geophysical Bulletin, vol. 7, including sections on geodesy, seismology, meteorology, terrestrial magnetism, and oceanography, may be obtained from the Scientific Liaison Office, National Research Council of Canada, Africa House, Kingsway, London, W.C.2.

The report of the National Physical Laboratory for the year 1955 is available from H.M.S.O., price 5*s*.

DSIR has published, at 4*s*., a report on "Fire Research 1955", with studies on outbreaks, growth, and suppression of fires, special fire hazards, fire-fighting equipment, etc.

Another DSIR report is "Measurement of Small Holes", a translation from the Russian, published at 8*s*. 6*d*.

DSIR's report on "Chemistry Research", 1955, 4*s*., gives findings on corrosion of metals, purification of elements and examination of waste and low-grade materials, radiochemical studies, high polymers, and microbiology.

The Meteorological Office of the Air Ministry have published a memoir on "Meteorological Results of the *Balaena* Expedition 1946–7" (H.M.S.O., 8*s*. 6*d*.). The floating factory *Balaena*, which sailed from Belfast on September 27, 1946, was built for United Whalers Limited. The *Balaena* sailed first to Tönsberg, Norway, to pick up crew. It then proceeded to the Antarctic via Cape Town. Part I of the memoir describes the organisation of the expedition and the meteorological arrangements. Aspects of the geography of the Antarctic are considered. Part II presents the meteorological results, including weather analysis over the Southern Ocean. Part III appraises the experimental forecasting service for the remote Antarctic whaling grounds. The lesson of weather analysis in the regions covered have a wider interest as part of the general circulation of the atmosphere.

Admiralty Bulletin No. 80 issued by the Royal Navy Scientific Service deals with a new underwater floodlight and is a brief report by G. G. Macneice of the Admiralty Research Laboratory at Teddington. Underwater cinematography, and more recently television, has always been faced with the difficult problem of lighting where natural illumination was insufficient. Until the work reported in this Bulletin, it was standard practice by cameramen to take the ordinary studio lighting equipment and enclose it in heavy, pressure-resisting cases whose transport on land or on the surface of the water proved extremely difficult. The new type of underwater illumination described does not necessitate heavy cases and consists of lamp bulbs where the hydrostatic pressure is resisted by the glass envelope of the bulb itself. A simple reflector made from Birmabright or anodised aluminium has been added behind the lamp and tested successfully with underwater television at depths down to 600 feet. They were employed during the *Comet* search operations near Elba.

"Combining for Research" describes the Research Associations set up by groups of firms to study their common scientific and technical problems. There are Associations for studying metals, fuels, engineering, textiles, food, etc. The booklet is obtainable from Charles House, 5–11 Regent Street, London, S.W.1.

Kodak have published an excellent little booklet, "Can Industrial Radiography Help You?" It describes how radiography can save machining costs, solve production problems, perfect welding techniques, etc.

SCIENCE ON THE SCREEN

Science on Television

The presentation of science to the public was the subject of a long and interesting discussion organised by the combined Institutes of Chemistry, Physics, and Biology earlier this year and, as might be expected, the claims of television as an ideal medium for putting over up-to-date information in an attractive way were put forward convincingly. Nevertheless, as the speaker (Mr J. McCloy) admitted, a good science television broadcast is more difficult to give than to receive. A live lecturer facing his audience is assured of their attention at the outset because they have come for the purpose of hearing him; the television lecturer has no such assurance and, like the actor, must capture his audience within the first few minutes and hold them.

When viewing science broadcasts it is sometimes apparent that the speakers consistently overrate the ability of the layman to follow a scientific argument, and they certainly overrate his scientific vocabulary. The work of P. E. Vernon some years ago* showed the surprising result that nearly half the population of Britain does not understand the meaning of words such as "automatically", "equivalent", or "analysis" which are not scientific terms in the accepted sense.

This illustrates the hopelessness of attempting to explain an abstruse subject in a way that can be followed by the majority of viewers (for majority it is), and the importance of accompanying the words with action or picture, however simple. As Faraday said: "The generality of mankind cannot accompany us one short hour unless the path is strewed with flowers."

The present BBC series of short science talks on topics of the day seems an admirable way of presenting recent developments, using, as it does, a question as a peg on which to hang some interesting relevant information. As an example, the subject of car sickness which was mentioned in July led to a description of the Faraday cage and the van de Graaff generator, both of which were demonstrated to viewers who might have wondered what they had to do with the question but who could not have been unimpressed.

An experiment of particular physiological and psychological importance was the demonstration of sub-threshold stimulation. This phenomenon, which has already been exploited in America with success as a form of advertising is produced by interposing a short headline in successive frames of a film which appears on the screen for only 1/25 second. This is well below the threshold of persistence of vision, but the short stimulus does affect a number of viewers and a form of subconscious registration takes place, enabling the contents of the headline (or advertising slogan) to be recalled some time after the film has ended. An experiment of this nature is particularly suited to a television audience, many of whom responded to an invitation to send in their impressions. To the research worker in social science the prospect of experiments carried out with the cooperation of a million guinea-pigs must be attractive, and it is possible that television will develop considerably as an aid to mass observation.

It is curious that although the visual accompaniment to science talks undoubtedly helps the viewer to understand what they are about, the memory of the programme is strongly influenced by the verbal description; in other words, a profusion of pictures cannot compensate for inadequate explanation. In television, as in ordinary lecturing, the ability of the speaker determines the success of the presentation. G. PARR

* *B.B.C. Quarterly*, 1950, vol. 5, No. 4, p. 206.

Mining for Nickel

Colour, sound, 16 mm., 45 minutes.
Made by: Film Graphics, New York.
Available from: Mond Nickel Company Ltd., Millbank, London, S.W.1.

The production of good scientific films is exceedingly difficult. At university level, where there is a great need, money is lacking; documentary film units, having plenty of ideas and vast know-how, are always on the look-out for a suitable sponsor; yet, the combination of money and suitable sponsor, does not necessarily produce a good scientific film. "Mining for Nickel", is an example of such a failure, where the sponsor was not crystal-clear from the beginning for which type of audience to make his film. The International Nickel Company of Canada hoped to demonstrate the magnitude of their operations and the size of their effort to maintain and to expand their nickel production; they spent about £30,000 to produce a forty-five-minute Eastman-color motion-picture, but they did not get across the aspect of their work they wanted to show.

What they did succeed in doing, however, may yet prove of far more lasting benefit to them. The film contains details of modern prospecting method, and an exceedingly clear picture of bulk-mining methods, such as many students of mining in this country would find difficult to learn from lectures or textbooks. For an audience of mining students, at universities, technical colleges, and even for senior schoolboys, this film should prove of great and enduring benefit. Excellent animation, and a number of good models, help to make the intricacies of square set mining methods, open-cast, blast-hole methods as well as shrinking and cut-and-fill practice, fascinating and memorable. Two-thirds of the film are devoted to these subjects.

From the film-makers' point of view, one can only guess at the tremendous difficulties of lighting an underground film in Eastman-color. Yet each shot is well lit, entirely clear in perspective, and well-chosen. A number of underground explosions have been filmed—at normal camera speed—and, so says the Press hand-out, expandable ciné cameras had to be used. In rocket cinematography, it is standard practice to build steel-cassettes strong enough to withstand the crash of the falling rocket; in this manner the famous views of the Earth's curvature were secured. The use of such cameras and cassettes in underground mining films is certainly a novel idea; unfortunately the shots secured in this spectacular manner add little to the general story.

A. R. MICHAELIS

High-speed Photography Congress

Cameras that can take millions of pictures a second will be on show during the Third International Congress on High-speed Photography which will be held in London from September 10 to 15. At least fifty papers will be presented, in two main groups: techniques and applications. Under techniques the following subjects will be discussed: inertialess shutters; mechanical optical drum cameras; image sampling; schlieren, interferometric, and stereoscopic techniques; x-rays; medium repetition rate cameras; photographic materials; instrumental aids. The applications group will include: biology and medicine; machine analysis; ballistics and explosives; aerodynamics; hydrodynamics; film evaluation.

An exhibition held in conjunction with the Congress will demonstrate the latest cameras, flash equipments, film analysers, and so on in use by commercial organisations, universities, and Government departments. About one-fifth of the exhibits are from overseas and most of them have never been seen before in this country. Cameras will be exhibited, ranging in weight from a few pounds to more than a ton, and in speed from a few hundred to a few million photographs a second. There will be a display of the uses of photography in solving industrial problems. High-speed ciné-films will be shown.

NEW SCIENTIFIC INSTRUMENTS

This feature is designed to provide information about new scientific instruments which have come on the market. The detailed facts in it are the responsibility of the manufacturers, being taken from literature supplied by the makers. The editor will welcome information from manufacturers about new scientific instruments they are putting on the market. As these notes are intended for the large section of our readership composed of professional scientists, etc., we depart from our customary practice and use symbols and abbreviations to the full in order to be able to convey the maximum amount of detailed information.

Barium Titanate Accelerometers and Strain Gauges

The G.E.C. Type E miniature sensitive yet robustly constructed barium titanate accelerometers ($\frac{3}{4}$ in. long and weighing 11 g.) are suitable for the detection and measurement of vibrations in the range 20 c/s–20 kc/s, and are stated to be accurate to within 10%, between 40 c/s and 10 kc/s. They operate between temperatures of -50 and $+100$°C.

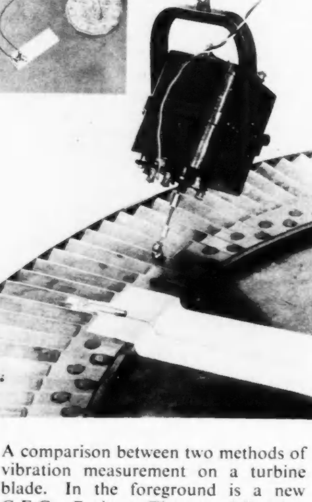
Their high sensitivity and small size depend on the properties of barium titanate whose high dielectric constant and piezoelectric activity are considerably greater than that of quartz. It is a ferroelectric material; by the application of a large d.c. voltage it can be permanently polarised electrically; it then behaves as a piezoelectric crystal of high activity. When such a crystal is compressed the resulting strain produces a minute potential difference across the faces of the crystal which is proportional to the compression. This reaction is reversible so that when subjected to alternating compression and expansion as in a rapid vibration, the piezoelectric crystal generates an electrical charge proportional to the force applied.

In the Type E barium titanate accelerometer a circular disc of barium titanate $\frac{3}{8}$ in. diameter and $\frac{1}{8}$ in. thick, silvered on both sides, is fixed between two pieces of brass one of which forms the base and is terminated by a 2 B.A. stud for fixing to the material or structure whose vibration characteristics are required. The other piece of brass acts as an inertia weight. The electrical charge which is generated by the crystal as a result of the vibrations is fed to a detector with a suitably high impedance such as a cathode follower, and the frequency and amplitude of the vibrations can then be observed on a cathode-ray oscilloscope.

The response to accelerations of up to 1000 g is linear, and its charge sensitivity of about 5 pC/g gives a voltage output of about 20 mV/g using conventional circuitry. The transverse sensitivity is less than 5% of the axial sensitivity, so the direction of vibration can be determined by the position in which the unit is mounted.

The G.E.C. vibration strain gauges, which can both detect and excite vibrations, consist of a thin bar of polarised barium titanate with silver electrodes on the two major faces. They are intended primarily for the determination of the various frequencies at which resonant vibration occur in mechanical structures, as well as their approximate strengths. They operate in the frequency range 20–50 c/s, are made in two standard sizes, $0{\cdot}75 \times 0{\cdot}25 \times 0{\cdot}035$ in. and $0{\cdot}75 \times 0{\cdot}125 \times 0{\cdot}035$ in., and are used cemented to the test object. The sensitivity is of the order of 0·1 volt output for an alternating displacement of 1 part in 10^6, and the operating temperatures are between -50 and $+100$°C. If the temperature exceeds 100°C in either the accelerometers or the strain gauges the piezoelectric properties can be restored by repolarisation.

The General Electric Co. Ltd., Magnet House, Kingsway, W.C.2.



A comparison between two methods of vibration measurement on a turbine blade. In the foreground is a new G.E.C. Barium Titanate Vibration Strain Gauge and behind it the much bulkier equipment for the electro-dynamic measurement of vibration.

Digitisers for Data Reduction and Remote Control Systems

With the establishment of high-speed digital computing techniques and the widespread interest in automation, it is often necessary to express a mechanical motion, which represents some physical quantity which it is desired to control, in digital form suitable for feeding into a computer or a controlling or recording device. Hilger and Watts Ltd. have developed both mechanical and optical digitisers for this purpose. The scales are binary coded and convert mechanical motions into the corresponding electrical signals coded in a scale of two arrangement.

The 1200-division mechanical digitiser is one of a standard range with brush pick-off. The metal disc is coded by division into 1200 parts in a special arrangement. Contact with the coded disc is made by stainless steel balls located in bushed holes in carrier plates. This unit divides a single rotation of a shaft into 1200 parts, without gearing. By connecting the output to a suitable decoder the position of the shaft may be read remotely on a lamp display, or the signal may be used to operate an electric typewriter, recorder, punch-card, magnetic tape, or other device. It may also be used in a servo-system for automatic control.

A small optical digitiser may be used for static or dynamic readings. It has a 2-in. diameter glass disc divided into 1000 parts coded in a binary scale, and minute cadmium selenide or other suitable photocell pick-offs. Various sizes are manufactured up to 12-in. diameter with 10,000 divisions. The output from these is suitable for feeding into high-speed computers.

Hilger & Watts Ltd., Watts Division, 48 Addington Square, London, S.E.5.

Standardised Glove Cabinets

A small glove cabinet Type X151/0 has been designed not only for handling isotopes and dangerous chemicals, but also for use where a clean atmosphere or a completely enclosed space is required such as in the handling of viruses and medical cultures. It is constructed of Melamine-coated Plimberite on a mild steel framework and has a transparent 3/16-in. Perspex front bonded with Epoxide resin. Normally there is one side opening, closed by a sliding door with a clamping device designed for easy operation while wearing gloves, but a second door can be provided the other end; these can be provided with air lock entries. A standard radioactive filter and diaphragm pump with pressure control for maintaining the interior at a constant small negative pressure is available.

Each box is tested and guaranteed to give a leakage rate lower than the standard Harwell requirements for gas-tightness for glove cabinets. The two front ports are for standard Harwell type gloves.

Townson & Mercer Ltd., Croydon, Surrey.

FAR AND NEAR

Night Sky in September

The Moon.—New moon occurs on September 4d 18h 57m, U.T., and full moon on September 20d 03h 19m. The following conjunctions with the moon take place:

September			
1d 12h	Venus in conjunction with the moon	Venus	1°N.
4d 23h	Jupiter „	Jupiter	6°N.
6d 17h	Mercury „	Mercury	1°N.
10d 07h	Saturn „	Saturn	2°N.
19d 14h	Mars „	Mars	11°S.

Venus is in conjunction with Pollux on September 2d 15h, Venus being 9°.5S.

The Planets.—Mercury is too close to the sun for observation. *Venus* rises at 1h 15m, 1h 30m, and 2h, on September 1, 15, and 30, respectively, and is a bright object with magnitude varying between −3·9 and −3·7, the visible portion of its illuminated disk increasing from 0·503 to 0·641. During this time its distance from the earth increases from 57 to 86 million miles and this increase more than compensates for the increase in the visible portion of the illuminated disk, in consequence of which it becomes less bright during the month. *Mars* rises at 19h 40m, 18h 35m, and 17h 25m, at the beginning, middle, and end of the month, respectively, the corresponding times of setting in the morning being 6h 10m, 4h 50m, and 3h 35m. Its stellar magnitude varies between −2·6 and −2·3 and the visible portion of its illuminated disk between 0·992 and 0·981, while its distance from the earth is 35·4 million miles on September 1 and 38·6 million miles on September 30. On September 7 it will be at its minimum distance—just over 35 million miles—and will lie a little east in R.A. of ψ Aquarii. The close approach of Mars in September will cause a considerable amount of interest, and observatories in various parts of the world will use the opportunity to make intensive studies of the planet's features. See article by de Vaucouleurs in our August issue, p. 320. *Jupiter* is too close to the sun in the early part of the month to be seen; at the middle and end of the month it rises at 4h 50m and 4h 10m, respectively, the times of sunrise on these dates being 5h 35m and 6h, respectively, from which it is obvious that observation of the planet will be difficult except towards the end of September when its declination is a little S. of σ Leonis. *Saturn* sets at 21h 30m, 20h 30m, and 19h 35m on September 1, 15, and 30, respectively. It approaches β Scorpii during the month and decreases slightly in brightness—magnitude 0·7 to 0·8—owing to its distance from the earth increasing from 941 to 983 million miles. Autumnal equinox occurs on September 23d 01h 36m.

Back Numbers of DISCOVERY

A reader of DISCOVERY has a complete set from 1947 to 1955 inclusive, for sale. He would like to hear from libraries or others anxious to buy this set.

New Signal Installation, Potters Bar

The new track layout and resignalling at Potters Bar, British Railways, Eastern Region, has been completed and a modern station has been constructed. The old mechanical signal box came in the way of one of the new platforms and it was necessary to dismantle it. Opportunity was taken to replace it by a modern power signal box, and the old semaphore signals by colour light signals. The new signal box is of modern and unusual design. The relay room, signal lineman's accommodation, and standby power plant are at ground level and the operating portion is built over the relay room. Large windows on three sides afford an uninterrupted view of all tracks controlled from the signal box.

The signalling system is controlled by the Metropolitan Vickers-GRS type NX system of route relay interlocking, which was modified so that the various routes could be operated by one man in a sitting position. The usual type of illuminated track diagram has been used, with a special console beneath it containing the switches and push buttons.

The plan of the area controlled from the signal box is engraved on the illuminated diagram, which is composed of a metal panel and finished matt green. The track circuits are coloured in pastel shades, contrasting colours being used for adjacent tracks for easy discrimination. The occupation of the track circuits by trains is indicated by the illumination of a small lamp placed in the centre of each track circuit. Red and green repeater lights representing the signals are also placed on the diagram at positions on the layout corresponding to the signals out on the track.

The console also has a miniature representation of the complete track layout, and the switches and push buttons controlling routes are placed at positions on the layout where signals are actually situated. To set up a route for a train the signalman only has to turn a switch at the commencement of the route and press a button at the end of it. This causes all the necessary points to be set and signals cleared. It is impossible for a signal to show "proceed" unless the points over which it reads are correctly set and locked and the line is completely clear. Relay interlocking prevents any conflicting moves being established.

Society of Chemical Industry

This year's Annual Meeting of the Society of Chemical Industry, held in London from July 9 to 14, marked its seventy-fifth birthday. The lectures centred round the theme "Achievements of Industrial Chemistry", and speakers reviewed the advances of the past twenty-five years. Four lectures were devoted to the new products of industrial chemistry, including plastics, artificial fibres, and antibiotics. Another series of lectures surveyed the tools of industrial chemistry, including the use of metals and non-metals in plant construction, as well as new manufacturing techniques and modern methods of recording and analysing the results of factory operations.

TV for College Students

San Francisco State College will try out an experimental programme next term whereby college students will listen to class lectures on television. It is believed this will be the first time such an experiment has been tried at the college level. The students will listen to lectures twice a week on television. Every second week the lectures will be supplemented by a two-hour discussion session. The project is financed by a $125,000 grant from the Fund for Advancement of Education. Its purpose is to help ease the shortage of classrooms and teachers.

Atomic Energy on the Farm

The use of atomic energy to develop rural areas of Australia was advocated by Prof. Harry Messel. "Imagine," he said, "having hundreds of package power reactors generating from 2000 to 10,000 kilowatts throughout Australia, through the outback of New South Wales, throughout the Northern Territory. Imagine nuclear power plants converting saline water into pure water and pumping it for irrigation purposes. Imagine this, and more, and you will see what nuclear energy can do for this great country of ours. This is not a dream—every bit of it will some day become a reality."

Electronic Stethoscope

Use of the electronic stethoscope, instead of the conventional binaural type, has been urged by Dr Oliver E. Turner, at the twenty-second annual meeting of the American College of Chest Physicians. Dr Turner said that certain heart and lung sounds have frequency ranges below the hearing threshold of many practitioners. Physicians developing deafness have particular difficulty in hearing these significant sounds with the conventional stethoscope. The electronic stethoscope, however, by amplifying inaudible frequencies, provides more complete information and hence improves the accuracy of diagnoses.

Students' Way of Life

An inquiry into the living conditions and housing of student communities is being undertaken by the World University Service with assistance from UNESCO. Problems common to a large number of countries will be studied, and practical solutions proposed.

The Soviet Journal of Atomic Energy

Arrangements have been made, as from August this year, to publish a verbatim translation of *Atomnaya Energiya*, the Soviet journal of atomic energy, as a supplement to the *Journal of Nuclear Energy*, which will henceforth appear monthly instead of bi-monthly. It is hoped that this arrangement will help Western scientists and technologists to keep abreast of Russian atomic-energy research. The subscription rate to the *Journal of Nuclear Energy* will be £7 or $20.00 per volume, and three volumes will be published a year.

Nuclear Power at Imperial College

The University of London has announced the appointment of Dr J. M. Kay to the newly instituted Chair of Nuclear Power at the Imperial College. Dr Kay is thirty-five; he graduated at Cambridge University, where he later held a University Demonstratorship in Chemical Engineering. In 1952 he was appointed Chief Technical Engineer at the Department of Atomic Energy's Industrial Group Headquarters at Risley, Lancashire. Since 1955 he has acted as a consultant in the field of nuclear power and in related industries.

Albert Medal for Sir Henry Dale

The gold Albert Medal of the Royal Society of Arts has been awarded for 1956, with the approval of H.R.H. The Duke of Edinburgh, President of the Society, to Sir Henry Dale, O.M., G.B.E., M.D., F.R.S., "for eminent service to science, particularly physiology".

New Theory on Rainfall

The Australian Scientific and Industrial Research Organisation reports the discovery of a new factor which might be influencing rainfall. The Chief of the Organisation's Division of Radiophysics, Dr E. G. Bowen, said that meteor dust streams, through which the earth passed regularly, might be influencing heavy rainfall on set calendar dates throughout the world. It had been discovered that rainfall was much heavier on certain calendar dates, and this heavy rainfall occurred exactly thirty days after the earth passed meteor streams from space. This was likely to have an important bearing on weather forecasting in the future. Dr Bowen said the CSIRO was now trying to relate the content of freezing nuclei in the earth's atmosphere to the meteor dust streams. It was thought that meteor dust streams produced freezing nuclei that caused rain-bearing clouds to bring heavy rainfall.

Investigations into the possibility that meteors could be influencing the earth's weather started in earnest after CSIRO had begun experiments into artificial rainmaking.

Automatic Machine-tools

The Poltava Locomotive Repair Works has built an automatic machine-tool run by one man which fully mechanises the entire process of covering locomotive wheels with hard alloys.

Psychical Research Prize

A Psychical Research prize essay is announced for the second year running by the Society for Psychical Research, 31 Tavistock Square, W.C.1, to the value of £50. There is a choice of subjects, and entries must be in by October 1.

ERRATUM

In "The Night Sky in July", DISCOVERY, July issue, p. 304, it was stated that a close approach of the planets Mercury, Venus, Jupiter, and the bright star Regulus was to take place on July 3. Whereas Mercury and Venus were in conjunction on July 2, Mercury was not in conjunction with Regulus until early August, and with Jupiter on August 9. At these times Mercury was not in conjunction with Venus, nor Jupiter with Regulus.

Classified Advertisements

OFFICIAL APPOINTMENTS

UNIVERSITY COLLEGE OF THE WEST INDIES

APPLICATIONS are invited for (*a*) Research Fellowship or (*b*) Junior Research Fellowship in Chemistry from organic chemists with research experience preferably on natural products. Appointments initially 3 years to commence as soon as possible after November 1, 1956. Salary scales (*a*) £900 by £50–£1200 by £50–£1600 p.a. (*b*) £750 by £50–£850 p.a. Entry point determined by qualifications and experience. Child allowance. F.S.S.U. Unfurnished accommodation at 5% basic salary or housing allowance. Passages up to 5 persons on appointment and normal termination.

Detailed applications (6 copies) naming three referees by September 10, 1956, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

APPOINTMENTS VACANT

BRITISH THOMSON-HOUSTON COMPANY LIMITED

THERE is a vacancy in the Research Laboratory at Rugby for a STAFF RESEARCH ASSISTANT to work in the Glass and Ceramic Group. A wide and interesting range of experimental work includes investigation of new materials for use in nuclear reactors. Applicants should possess G.C.E. at A level in physics and chemistry, and should not be liable for military service.

Applicants are invited to write to the Director of Research, the British Thomson-Houston Co. Ltd., Rugby, giving details of their age, qualifications, and experience, quoting reference RH.

RESEARCH LABORATORY ASSOCIATED ELECTRICAL INDUSTRIES LIMITED

TECHNICAL ASSISTANTS are required in the SOLID STATE PHYSICS SECTION for work in connexion with semi-conductors.

Applicants should have completed their National Service, and be in possession of the Ordinary National Certificate in Applied Physics or similar qualification. Some practical experience in Laboratory techniques would be an advantage, but not essential.

Excellent opportunities for promotion to higher grades by study for additional qualifications are given, and the appointments are pensionable.

The Laboratory serves a large group of companies. It is situated in pleasant rural surroundings near Reading with a fast train service to London. Please write giving full details of qualifications and experience, quoting reference No. SS/A/1 to Personnel Officer.

Research Laboratory,
ASSOCIATED ELECTRICAL INDUSTRIES LIMITED
Aldermaston Court,
Aldermaston, Berkshire

THE BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

DIRECTOR OF RESEARCH

THE Council of the British Electrical and Allied Industries Research Association invite applications for the post of Director of Research. The Association which was established in 1920 and receives grant aid from the Department of Scientific and Industrial Research, serves and is well supported by the supply industry of Great Britain and the Commonwealth; manufacturers of electrical plant, machinery, cables, and appliances; large users of electrical energy and suppliers of structural, magnetic, and insulating materials. Large new laboratories have just been built and equipped at Leatherhead; in addition, there are field stations at Shinfield and Cranfield and there is a section of the old laboratories at Perivale which will remain in use for a few years. The Association which has an annual budget of about £350,000 and staff of 330, is looking forward to a substantial increase in the scale of its operations. The present scope of its scientific work covers the generation, transmission, and distribution of electricity; utilisation of electricity by public utilities, industry, agriculture, and horticulture and in the home; study of insulating, magnetic, and structural materials for electric equipment; design of switch-gear, transformers, power plant, electronic equipment, protective gear, instruments, consumer devices, and other products. The Director will be encouraged to pursue his own scientific interests within the general scope of the Association's programme. The staff of the Association have reasonable freedom to publish scientific work and to take part in the work of scientific societies and international organisations of interest to the electrical industry. The salary of the Director, depending on qualifications and experience, will be not less than £3000 per annum initially with superannuation under F.S.S.U. Applications for the post which must be received by October 1, 1956, should be addressed to: The Chairman of Council, The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey, and envelopes should be marked "Director—Confidential".

M.W.T. RADAR. Marconi's Wireless Telegraph Company Limited, Chelmsford, invite applications for the following appointments in their Radar Division.

SYSTEMS DESIGN ENGINEER: Applicants must hold an H.N.C. as a minimum technical qualification and should have some operational experience of ground radar equipment. Experience in evolving radar systems desirable.

SYSTEMS PLANNING ENGINEER: Applicants must have installation experience of ground or ship-borne radar equipment. Technical qualifications up to H.N.C. standard desirable but not essential if applicants have sound experience.

SALES ENGINEER: This appointment is suitable for applicants who possess good technical experience of ground radar, obtained for example in a technical branch of the R.A.F. This experience should be coupled with a good technical qualification such as a University Degree or H.N.C.

All the above appointments are permanent and pensionable. Applications will be treated as confidential and should be addressed to Marconi's Wireless Telegraph Co. Ltd., Dept. C.P.S., Marconi House, 336/7 Strand, W.C.2. Please quote Ref. 2060A.

ATOMIC POWER

PHYSICISTS

Physicists are required in the Atomic Power Department of the English Electric Co. Ltd., at Whetstone, near Leicester.

The vacancies are for Honours Graduates to work on general physics and experimental problems in connexion with nuclear reactors.

Previous research experience would be an advantage.

Apply to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 1813C.

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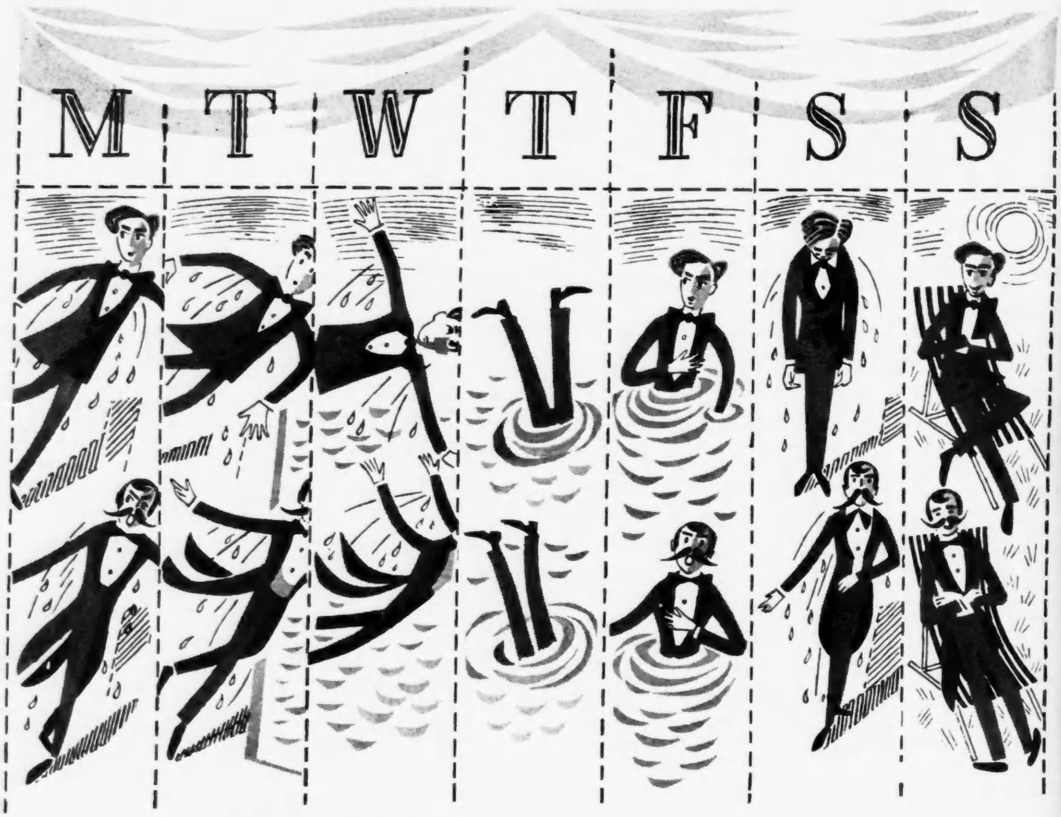

Every week-night for 8 months,
two West End actors were pushed fully clothed into a swimming
pool on the stage. Strange as it may seem, the wardrobe mistress

Never wet on Sundays

was not a bit perturbed, because the men were clad from head to foot
in garments that did not shrink,
always retained their creases,
and were fully dried out and ready to wear
by the next performance. The secret was, clothes made entirely of ' Terylene ' polyester fibre.
This new all-British fibre has a great future.
All sorts of things – from fishing nets to trousers, from curtain fabrics to women's underwear –
are being made from it, and every day brings an extension of its uses.
At Wilton, in North Yorkshire, I.C.I.'s ' Terylene ' plant, recently enlarged,
will this year reach a productive capacity
of 22 million lb. annually.

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